Learning in the Metaverse: Challenges, Opportunities, and Threats

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Dedication

Dedicated to,

All who are born to explore,

And chase their wildest schemes.

All who are meant to soar,

And follow their heart,

No matter where it leads

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I hereby declare that this submission titled "Learning in Metaverse: Challenges, Opportunities and Threats" is my own work. To the best of my knowledge it contains no materials previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any degree or diploma at NUST SEECS or at any other educational institute, except where due acknowledgement has been made in the thesis. Any contribution made to the research by others, with whom I have worked at NUST SEECS or elsewhere, is explicitly acknowledged in the thesis. I also declare that the intellectual content of this thesis is the product of my own work, except for the assistance from others in the project's design and conception or in style, presentation and linguistics, which has been acknowledged. I also verified the originality of contents through plagiarism software.

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Abbreviations

UDL	Universal Design for Learning
MEEM	Model for enhancing education through Metaverse
DEIB	Diversity, Equity, Inclusion, and Belonging
VR	Virtual Reality
AR	Augmented Reality
XR	Extended Reality
NASA	National Aeronautics and Space Administration

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Abstract

The Metaverse, a virtual shared space, is becoming an increasingly popular platform for social interaction and learning. However, current approaches to learning in the Metaverse are often limited by the lack of a cohesive framework for designing and delivering educational experiences. The study aims to overcome this challenge and propose a generic framework to introduce six broad dimensions that guide the design of learning experiences in this immersive environment. The given research study builds on the integration of UDL and Five W's and One H to provide a theoretically sound learning framework for the Metaverse. The framework thus introduced will help in understanding the dimensions that have a crucial role in learning in the Metaverse.

These six dimensions namely what, how, why, who, where, when refer to the representation, action and expression, engagement, identity, time, space respectively. The framework covering these dimensions is referred to as MEEM. It conveys an understanding of how the learning experiences in the Metaverse are affected by these dimensions and why they are important for providing an effective learning environment for learners in the Metaverse. By covering the key aspects of learning in the Metaverse offered by the framework, we can elaborate what teaching and learning in the Metaverse entails. Furthermore, the framework will keep evolving with growing research and development in the Metaverse and can be used to accommodate the future learning perspectives in the Metaverse.

Chapter 1

Introduction

This chapter discusses the research background of the Metaverse and its use as a platform for teaching and learning. After providing a brief overview of the Metaverse, the chapter goes on to discuss the primary motivation and other reasons for conducting a study on Learning in the Metaverse.

1.1 Background

The Metaverse, first popularized by science fiction author Neal Stephenson in his 1992 novel Snow Crash, has recently gained significant attention as a platform for learning and development [1]. The Metaverse offers the potential for immersive, interactive, and personalized learning experiences that can engage and motivate learners in ways that traditional methods may not. Despite its potential, the Metaverse currently lacks a comprehensive learning framework that can effectively support the acquisition and transfer of knowledge within virtual environments [2].

One major challenge in developing a learning framework for the Metaverse is the lack of understanding of how people learn within virtual spaces. Research has shown that learning in virtual environments differs from learning in the physical world [3]. In virtual environments, learners may not have the same level of physical interaction with the learning material, and may not receive the same level of feedback as they would in a physical setting [4]. As a result, traditional teaching methods may not be as effective in virtual environments [4].

Additionally, the Metaverse presents unique challenges in terms of learner engagement and motivation. Research has shown that learners may be more likely to disengage in virtual environments due to the lack of social presence and the lack of physical consequences for actions [4, 5]. This can lead to a decrease in motivation and a decrease in learning outcomes [4, 6].

Another challenge in developing a learning framework for the Metaverse is the lack of standardization and consistency across virtual environments [7]. Different virtual environments may have different user interfaces, different learning materials, and different methods of assessment, making it difficult for learners to transfer knowledge between environments. This lack of consistency can lead to confusion and frustration for learners, and may impede their ability to effectively learn and transfer knowledge within the Metaverse [8].

Recent research has begun to address these challenges, with a focus on developing personalized and adaptive learning approaches that take into account the unique characteristics of virtual environments [9, 10, 11]. For example, some studies have explored the use of artificial intelligence and machine learning techniques to support personalized and adaptive learning in the Metaverse [12]. Other research has focused on the use of gamification and game-based learning as a way to increase learner engagement and motivation in the Metaverse [13, 14, 15].

Despite these efforts, there is still a need for further research and development in the area of learning frameworks for the Metaverse [16]. By addressing the challenges of learning in virtual environments, it may be possible to create a learning framework that can effectively support the acquisition and transfer of knowledge within the Metaverse, ultimately leading to improved learning outcomes and increased opportunities for growth and development [17, 18, 19].

In a nutshell, the lack of a comprehensive learning framework for the Metaverse presents a significant challenge in the field [20]. While there has been progress in recent years in developing personalized and adaptive learning approaches for the Metaverse, there is still a need for further research and development in this area. By addressing the challenges of learning in virtual environments, it may be possible to create a learning framework that can effectively support the acquisition and transfer of knowledge within the Metaverse, ultimately leading to improved learning outcomes and increased opportunities for growth and development.

1.2 Motivation

The Metaverse provides enhanced learning opportunities for learners in an immersive environment where they are indulged in the practical experiences which helps them to transfer their learning in the real world. However, there is a need for a learning framework which can help in delivering effective learning experiences in the Metaverse [21].

One of the key motivations for developing a framework for learning in the Metaverse is that it is a completely new and different kind of environment. Unlike traditional learning environments, the Metaverse is not bound by the physical constraints of the real world [22]. This means that it is possible to create learning experiences that are not possible in the real world, such as simulations, virtual field trips, and immersive role-playing activities. However, this also means that the learning experiences in the Metaverse will be very different from those in the real world and will require new approaches to teaching and learning .

Another motivation for developing a framework for learning in the Metaverse is that it will enable more people to access education and training. The Metaverse is a virtual space that can be accessed from anywhere, at any time, and on any device. This means that people who are unable to physically attend a traditional learning institution, due to geography, disability, or other barriers, will be able to access education and training in the Metaverse [23]. This has the potential to significantly increase the reach and impact of education and training programs, and to make them more inclusive and accessible [24, 25].

There are also a number of other benefits to developing a framework for learning in the Metaverse. For example, the Metaverse provides a safe and controlled environment for learning, which allows learners to take risks and make mistakes without fear of real-world consequences. This can be particularly beneficial for learners who may be hesitant to try new things or who may be anxious about failing in a traditional learning environment. In addition, the Metaverse allows for personalized and adaptive learning, as it can track and respond to the progress and needs of individual learners. This can help to ensure that learners are receiving the support and guidance they need to succeed.

However, there are several challenges to developing a framework for learning in the Metaverse [20, 26, 27]. One of the main challenges is the lack of research and understanding of how people learn in this new environment. While there is some research on learning in virtual reality environments, the Metaverse is a much more complex and immersive environment, and there is still much to be learned about how people learn in this new space [28, 29, 30]. Another challenge is the need to design and develop new learning technologies and tools that are tailored to the unique characteristics of the Metaverse [8, 9, 14, 18]. This will require significant investment in research and development, as well as collaboration between researchers, educators, and technology companies [31].

Despite these challenges, the potential benefits of developing a framework for learning in the Metaverse are significant. It has the potential to revolutionize the way we access and experience education and training, and to make it more inclusive, accessible, and effective. As such, it is important for researchers, educators, and policy makers to continue to explore and develop this new and exciting learning environment.

1.3 Study Overview

The purpose of this study is to develop a learning framework for the Metaverse. The Metaverse is a virtual space that allows users to interact with each other and with virtual objects in real-time, creating a shared, immersive, and interactive environment. Since the Metaverse allows for the creation of learning experiences that are not possible in the real world, there is a need to develop a learning framework for it. However, the framework proposed in this study is a foundation to explore the vast domain of the Metaverse. The framework will evolve with the growing research in the Metaverse.

This research study is based on the integration of UDL and Five W's and One H for introducing six broad dimensions for learning in the Metaverse. Here, the UDL framework provides three dimensions (what, how, and why) for effective learning that are based on three brain networks (Recognition, Strategic and Affective). And the Five W's and One H framework provides six dimensions for giving a holistic description of a learning environment. By combining these two frameworks in a cohesive manner, the research tends to introduce a generic framework for learning in the Metaverse.

The six dimensions of the newly introduced framework referred to as MEEM include Representation, Action and Expression, Engagement, Time, Space and Identity for the

Metaverse. The first three dimensions correspond to the what, how, and why dimensions of UDL and the other three dimensions correspond to who, where, and when dimensions of the Five W's and One H framework and they have been found to be of significant importance from the literature. By combining these six dimensions in a framework, the main elements are highlighted that play a crucial role for learning in the Metaverse.

The framework provides a basis for building a narrative for learning in the Metaverse. This narrative will motivate future researchers to build on the framework and explore its broad dimensions. As the Metaverse is in the early stages of evolution, the framework will continue evolving with the latest research findings. It is expected that the framework will contribute to developing a foundational understanding of the crucial elements for learning in the Metaverse.

CHAPTER 2

Literature Review

The Metaverse is said to become widespread very soon, which have started a debate on its potential applications. The most important application to consider is effective facilitation of virtual learning environment within the Metaverse framework. In this chapter, we give a detailed review on literature. The chapter specifically targets the need for developing a learning framework by using Metaverse as a resource. Further, we present some key factors that give a detailed layout that needs to be implemented in order to effectively execute the learning platforms using Metaverse.

2.1 Need for learning in the Metaverse

The Metaverse has the tendency to provide significant learning opportunities through interactive environments of virtual reality, the learners can have a real world life experience with 3D virtual environments [32, 33]. Which provides the learner with very basic facilities that are absent in the traditional learning environments, which pose some barriers for effective learning in terms of the time, cost and space. Contrary to traditional learning the Metaverse can effectively overcome these barriers by providing better discern under controlled and active understanding environment with ease of usability [33]. In addition, it offers a highly immersive and interactive experience for the learner, the ability to access and share a wide range of resources and the ability to facilitate collaboration or social interaction among learners makes Metaverse the best candidate for such platforms [34]. However, to navigate within the vast Metaverse, there is a need for a framework for learning in the Metaverse to be implemented beforehand. Also, the increasing popularity of virtual environments have shown that these platforms have great potential to become good learning platform as well. These features make the Metaverse an appealing platform for a wide range of learning contexts, including formal education, professional development, and informal learning [35, 36].

The world has shifted to remote based work-spaces after the COVID-19 pandemic, which is another supporting reason for developing and enabling a Metaverse based learning framework. As, discussed earlier, the potential for this kind of virtual environment to replace traditional, physical learning spaces are encouraging [37, 38]. Thus, the Metaverse offers to create a potential platform that can provide learning environment which is more flexible, adaptable and allow learners to access and engage with material from any location at any time [39]. In addition, it can provide an opportunity for learners to engage with material in a more interactive and immersive way, potentially leading to deeper understanding and retention of the material [40]. However, the benefits for the learning are theoretically high but it is important to consider different appraches for the effective development of its framework and practical implementation. One approach to develop such a learning framework for the Metaverse, is to draw upon existing research on learning in traditional and physical environments to adapt these same principles in virtual context. Such as, scaffolding and feedback in facilitating learning [41]. Where, scaffolding refers to the use of support or guidance to aid the learners to navigate a certain task or concept, while feedback refers to provide the learners with information about their performance and suggest methods for improvements. These principles can be effectively be applied in the Metaverse by designing a level based learning experiences, that can provide appropriate support and guidance to the learner with effective feedback and mark their progress in form of levels. Another important factor to consider is the social interaction. The collaborative learning can be an effective way to facilitate learning, as it allows learners to share knowledge and ideas, receive feedback from peers, and engage in problem-solving activities [40, 41]. In the Metaverse learning environment, collaboration can be facilitated through the use of virtual tools and added features, that include chat rooms, forums and shared virtual spaces.

A key element to consider in developing a learning framework for the Metaverse is the role of motivation and engagement. Although, it doesn't seem much effective but it has be observed that appropriate amount of motivation and user engagement are key psychological factors that make these platform absolute for learning. As, it impacts the learner's willingness to engage with the material and persevere through challenges. In order to increase the motivation and engagement the Metaverse learning environment should be interactive and immersive [42]. This is easily implements in the Metaverse as it already relies on a range of technologies, including virtual reality (VR) and augmented reality (AR), which have the potential to create highly immersive and interactive learning experiences [33]. These technologies can be used to create simulations and experiential learning opportunities that allow learners to engage with material in a meaningful and authentic manner. However, it is arguable that VR and AR may have accessibility issues for the learners. As, these technologies are not widely available and may not be available in such a way anytime in near future. This imposes a challenge, which should be addressed in designing the framework of Metaverse learning environment [2, 20, 34].

The customization facility for the learner can impact and further facilitate not just by means of visual representation on the platform but also giving the learner an identity. This provide them with a sense of ownership and control over their learning experience, which may increase their motivation and engagement [42]. There are many possible ways of customization, one of which is role of avatar design. Avatars and agency within the Metaverse are visual representations of the learner within the virtual environment and highly impact the learner's sense of identity. Hence, converging learner's to Metaverse platforms. The addition of avatar may reinforce societal biases and stereotypes on these platforms, which can be easily addressed in the design of a learning framework for the Metaverse by setting up content moderation [41, 43].

In addition to these specific considerations, there is a more general challenge that must be addressed in the development of a learning framework for the Metaverse. The challenge imposes a question, what are suitable methods of taking assessment in Metaverse learning environment. As, discussed traditional methods cannot be implement. Some of the assessment can be given in form of self paced projects but much of the assessments are needed to be adapted in virtual context, with technology at hand it seems implementable [44, 45]. There is also a need for setting up a guidelines for learners who may be new to the Metaverse or may have limited experience with virtual environments, that can give them initial support and aid to navigate this new environment [41].

The Metaverse offers a unique platform for learning, with the potential to create immersive, interactive, and flexible learning environments that give real experience in virtual environments. However, in order to effectively facilitate learning within this virtual environment, it is important to consider a range of factors, including scaffolding and feedback, collaboration and social interaction, motivation and engagement, the role of technology, avatar design and customization, and general challenges such as assessment and supporting new learners. By considering these factors and drawing upon existing research on learning in traditional environments and highlighting the challenges, opportunities, and threats for learning in the Metaverse, we can effectively design a learning framework for the Metaverse that meets the needs of learners and facilitates meaningful and effective learning experiences.

2.2 Challenges for learning in the Metaverse

The Metaverse offers substantial potential benefits for learning, including the ability to create immersive and interactive experiences by facilitating collaboration and social interaction among learners. In addition to these benefits there are a number of challenges that must be considered when developing a learning framework for this virtual environment. This section discusses in detail, some of the key challenges for learning in the Metaverse.

The lack of cohesive frameworks for learning in the Metaverse and the potential of the Metaverse for distraction and disorientation is one of the challenges that needs to be addressed [46]. The notifications, pop-ups and other interruptions, which disrupt learners' focus and attention are potential distractions for learners in the virtual environment of the Metaverse [47]. Also, the virtual environment of the Metaverse may be unfamiliar or disorienting for some learners, making it difficult for them to navigate and engage with the material. In order to address these challenges, the learning framework must be designed with reduced distractions, which is an open challenge and setting-up clear guidelines that support the fresh learners navigate in the virtual environment is much needed part of the framework [41].

Another challenge for learning in the Metaverse is the potential for technological issues or difficulties. The Metaverse relies on a range of technologies, including VR and AR, which may be prone to technical issues or may not be widely available or easy to use for all learners, In addition, there may be issues of accessibility for some learners, as the Metaverse may not be accessible to all users due to technological or physical limitations

[41]. To address these challenges, it may be helpful to design learning experiences that are flexible and adaptable, and to consider the potential technological limitations of the Metaverse when designing learning experiences.

A third challenge for learning in the Metaverse is the potential for social and cultural issues to emerge. The virtual environment of the Metaverse allows for the creation of avatars, which are visual representations of the learner within the virtual environment. However, avatars may reinforce societal biases and stereotypes, and there is a risk that these biases may carry over into the virtual environment of the Metaverse [41, 43]. In addition, the Metaverse may not be inclusive or accessible to all learners due to social and cultural barriers. These challenges needs to be addressed, in order to form an environment that is helpful, inclusive and respectful of diversity [48]. The potential social and cultural implications of the Metaverse when designing learning experiences are exceptional.

In a nutshell, the Metaverse shows a substantial potential to becomes learning-hub but there are a number of challenges that needs to be addressed appropriately i.e. distraction, disorientation, technological issues and sociocultural issues. Only, if these challenges are met and the framework in designed to further resolve such issues, the Metaverse will be able to create a meaningful and effective learning experience for learners throughout the world.

2.3 Opportunities for learning in the Metaverse

The Metaverse is a rapidly growing field that offers numerous opportunities for learning and education. In 2022, the global market for Metaverse stood nearly at 65.5 billion $, which rise to 82 billion $ in 2023. It is estimated that before 2030, the market size will be near to 936.6 billion $ [49].

One of the main benefits of the Metaverse for learning is the ability to create immersive and interactive experiences that can engage and motivate learners in a way that traditional methods may not be able to. For example, in a virtual field trip, students can visit and explore historical or scientific locations and interact with artifacts or environments in a way that would not be possible in the physical world [50]. In addition, the Metaverse allows for the creation of personalized learning experiences, where students can learn at their own pace and follow their own interests, as well as collaborate with other learners in real-time.

Another advantage of the Metaverse for learning is the ability to access and share knowledge and resources from anywhere in the world. Virtual classrooms and online course platforms, such as those offered by Coursera or edX, have been widely adopted in recent years, allowing students to learn from top professors and institutions from around the globe [51, 52]. Moreover, the Metaverse offers the potential for experiential learning, where students can apply and practice their skills in realistic and authentic environments, such as virtual internships or simulations.

In addition to traditional academic subjects, the Metaverse also offers opportunities for learning in areas such as communication, collaboration, problem-solving, and critical thinking, are all the essential skills for success in today's digital age. For example, in a virtual role-playing game, students can practice teamwork and decision-making, while in a virtual debate, they can develop their public speaking and critical thinking skills.

In conclusion, the Metaverse offers exciting and innovative opportunities for learning and education, with the potential to engage and motivate learners, access and share knowledge and resources, and develop essential skills for the digital age. While there are challenges and limitations to consider, the Metaverse has the potential to transform education and learning in the 21st century.

2.4 Threats for learning in the Metaverse

The Metaverse offers numerous opportunities for learning and education but it also presents a range of threats and challenges that must be addressed. One major threat to learning in the Metaverse is the potential for digital divide, where access to technology and the internet is not equally available to all students [53]. This can create disparities in education and limit the ability of some students to fully participate in online learning and the Metaverse. In addition, there are concerns about privacy and security, as students and educators may be vulnerable to cyber-attacks or data breaches when using virtual platforms and networks [54].

Another threat to learning in the Metaverse is the potential for inappropriate or harmful content, including cyberbullying, harassment, or extremist ideologies [41, 43]. It is important for educators and policymakers to establish guidelines and protocols to ensure a safe and respectful learning environment in the Metaverse.

There are also challenges related to the design and effectiveness of virtual learning environments. Virtual reality and online course platforms can be difficult to navigate and may not be intuitive for all students. In addition, there is a lack of research on the long-term impact of virtual reality on learning and retention, and it is unclear how well students will retain knowledge and skills learned in the Metaverse [55].

Finally, the Metaverse may also pose a threat to the social and emotional well-being of students, as it can lead to isolation and disconnection from the physical world and face-to-face interactions [56]. It is important for educators to consider the balance between virtual and in-person learning and to provide opportunities for social and emotional support for students.

In a nutshell, while the Metaverse offers numerous opportunities for learning and education, it also presents a range of threats and challenges that must be addressed. These include issues related to digital divide, privacy and security, harmful content, design and effectiveness, and social and emotional well-being. It is important for educators, policymakers, and researchers to address these challenges and ensure that the Metaverse is used ethically and responsibly for learning.

Chapter 3

Research Design

This chapter discusses the direction of the research study, the methodology used to conduct the study and the underlying research questions which need to be answered. Overall, this section will contribute to developing an understanding of the main variables affecting the study on Learning in the Metaverse.

3.1 Problem Statement

The Metaverse is a virtual shared space that comprises of persistent worlds and the people who inhabit them. It has the potential to revolutionize the way we live, work, and interact with each other. However, navigating and thriving in the Metaverse can be overwhelming due to its complexity and dynamic nature [2]. There is a pressing need for a learning framework that can describe what learning in the Metaverse entails and help individuals and organizations develop the skills and competencies needed to effectively communicate and collaborate in this environment [57]. A learning framework for the Metaverse could have numerous benefits, including helping individuals and organizations navigate and thrive in the Metaverse, driving innovation and economic growth, and fostering inclusivity and equity [58]. However, developing such a framework will present a number of challenges and considerations, including the need to address the complexity and diversity of the Metaverse, ensure accessibility and inclusivity, balance structured learning with flexibility and adaptability, and consider the sustainability of the framework.

3.2 Research Objectives

The research objectives for the given research study are given below:

- **Challenges:** To identify the challenges for using Metaverse as a platform for teaching and learning
- **Opportunities:** To develop a cohesive framework for the Metaverse
- **Threats:** To investigate the threats for learners in the Metaverse

3.3 Research Questions

The research questions for the given research study are given below:

- **Challenges:** What are the key challenges in using Metaverse as a learning environment?
- **Opportunities:** How can we propose a learning framework for the Metaverse based on the gaps from existing learning models?
- **Threats:** What are the key threats for learners in the Metaverse?

3.4 Research Methodology

The research methodology used for the given research study is Exploratory Research. Exploratory research is a type of research that aims to gather preliminary information about a topic or issue and to explore the potential avenues for further investigation [59]. It is often used when there is a lack of understanding or knowledge about a particular topic, or when the research question is still being developed. Since the given research study is an initial step for proposing a learning framework for the Metaverse, it is important to use exploratory research to identify the important aspects of learning in the Metaverse. The step by step process followed using the above research methodology is shown below:

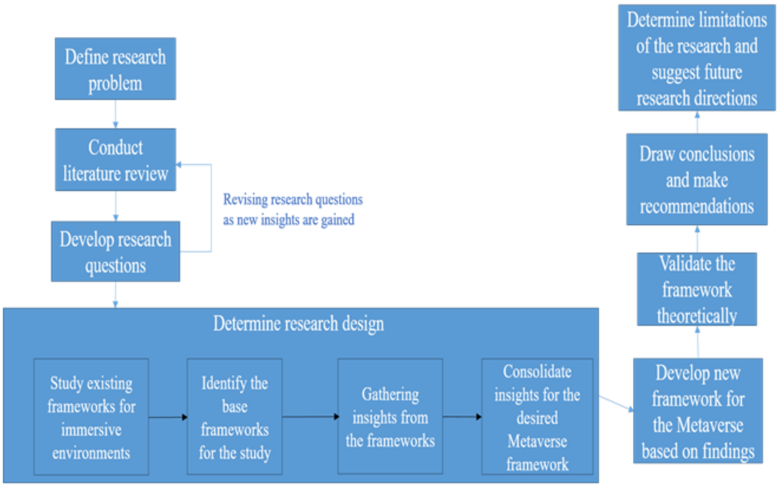
Define research problem
Conduct literature review
Develop research questions
Revising research questions as new insights are gained
Determine research design
Study existing frameworks for immersive environments
Identify the base frameworks for the study
Gathering insights from the frameworks
Consolidate insights for the desired Metaverse framework
Develop new framework for the Metaverse based on findings
Validate the framework theoretically
Draw conclusions and make recommendations
Determine limitations of the research and suggest future research directions

Figure 3.1: High Level View of Research Methodology

3.5 Combined System Model for Learning in the Metaverse

The combined system model for learning in the Metaverse is comprised of three main sections, Challenges, Opportunities and Threats. “Challenges” mean the potential roadblocks for using Metaverse as a platform for learning. “Opportunities” mean the potential benefits of the Metaverse as a learning environment. “Threats” mean the privacy and security issues that arise when learners enter the Metaverse for learning. The combination of these three factors provides a holistic overview of learning in the Metaverse and helps in understanding the benefits of learning in the Metaverse in contrast with the traditional learning environments. The diagrammatic representation of the model along with the key factors is shown below:

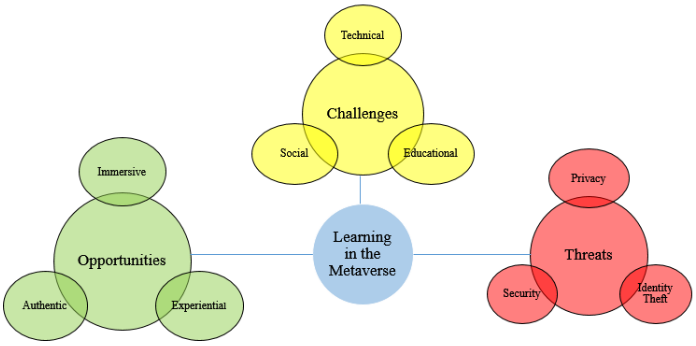

Figure 3.2: Combined System Model for the Thesis

Chapter 4

Proposed Model for Learning in the Metaverse

Learning in the Metaverse holds great significance for revolutionizing the future of education. However, to unlock the full potential of learning in the Metaverse, there is a need for a cohesive framework that guides the design of learning experiences. To develop such a framework, the research study builds on some of the existing learning frameworks and their key integration for the Metaverse which is discussed below:

4.1 UDL for the Metaverse

There is a need for Universal Design for Learning (UDL) in the Metaverse because virtual environments, such as online games, simulations, and virtual reality (VR) applications, can present unique challenges in terms of accessibility and inclusivity. UDL is a framework for designing educational experiences that are accessible and effective for all learners, based on the principle that all learners have different needs and preferences, and that educational experiences should be designed to accommodate these differences [2, 60].

One reason why UDL is particularly important in the Metaverse is that virtual environments can provide a wide range of formats and modalities for information and content, which can make it difficult for some learners to access and engage with the material. For example, a learner with a visual impairment might have difficulty accessing content that is presented primarily in text or video format, while a learner with a hearing impairment might have difficulty accessing content that is presented primarily in audio format. By applying the UDL principle of multiple means of representation, which involves providing multiple formats and ways to access and interact with content, educators and designers can help ensure that all learners can access and engage with the material in the Metaverse.

Another reason why UDL is important in the Metaverse is that virtual environments can provide a wide range of opportunities for learners to demonstrate their understanding and skills, and to create and express themselves in the virtual environment. However, not all learners may have the same preferences or abilities when it comes to these activities [53, 60]. For example, a learner who is shy or introverted might have difficulty expressing themselves through spoken or written communication, while a learner with a physical disability might have difficulty demonstrating their skills through physical actions. By applying the UDL principle of multiple means of action and expression, which involves providing learners with multiple ways to demonstrate their understanding and skills, and giving them opportunities to create and express themselves in the virtual environment, educators and designers can help ensure that all learners have the opportunity to participate and demonstrate their learning in meaningful ways in the Metaverse [33, 39, 48].

By applying the UDL principle of multiple means of engagement, which involves providing learners with a variety of ways to engage with the learning material and each other, and encouraging them to take an active role in their own learning, educators and designers can help ensure that all learners have the opportunity to stay motivated and engaged in the learning process in the Metaverse. For example, a learner might participate in a virtual role-playing game that allows them to choose their own path and make decisions that affect the outcome of the game. This can provide a unique and engaging learning experience that is tailored to the learner's interests and motivations.

Hence, the Metaverse can be a great learning environment to implement the UDL principles because it allows educators and designers to create learning experiences that are flexible, adaptable, and engaging for all learners. By applying the UDL principles of multiple means of representation, action and expression, and engagement, educators and designers can create learning experiences in the Metaverse that are accessible and effective for all learners, regardless of their needs and preferences [61].

Research has shown that UDL can be effective in improving the accessibility and inclusivity of learning experiences in the Metaverse [62, 63]. For example, a study by Rose et al. (2014) found that applying UDL principles to the design of a virtual chemistry lab resulted in improved student performance and engagement, as well as increased accessibility for students with disabilities. These findings demonstrate the potential for the Metaverse to be a great learning environment for implementing the UDL principles and improving the accessibility and effectiveness of learning experiences for all learners [64].

4.2 Five W's and One H and the Metaverse

The Five W's and One H are a set of questions that are often used to gather information and seek a better understanding of a particular topic. In the context of the Metaverse, these questions can help understand the additional dimensions of time, space, and identity that are not explicitly covered by the Universal Design for Learning (UDL) framework.

One way that the Five W's and One H can help to understand the Metaverse is by providing a framework for examining the context in which virtual experiences take place. The "when" and "where" dimensions of the Metaverse refer to the time and space in which virtual experiences occur. This includes the context and environment in which learning experiences occur within the Metaverse, as well as the time frame in which the experiences take place (i.e. present, past, or future). By answering questions about when and where, we can better understand the context in which virtual experiences occur and how they may differ from physical experiences.

The "who" dimension of the Metaverse refers to the identity of the user and the virtual avatars or characters they may use within the Metaverse. In recent years, there has been a growing interest in understanding how identity is constructed and performed within virtual spaces, and how this may differ from physical spaces [43, 65]. By answering questions about who is involved in virtual experiences, we can gain insight into the ways in which identity is constructed and expressed within the Metaverse.

Thus, the Five W's and One H can provide a useful framework for examining the additional dimensions of time, space, and identity in the Metaverse, and can help in better understanding the context in which virtual experiences take place. Some examples of how this framework might be used to examine the Metaverse could include:

- Examining how virtual events or gatherings are structured in terms of time and space, and how this may differ from physical events.
- Analyzing how virtual avatars or characters are used to express identity within the Metaverse, and how this may differ from physical identity expression.
- Investigating the ways in which virtual experiences may be shaped by the time and space in which they occur, and how this may impact user engagement and learning.

4.3 Integration of UDL and Five W's and One H for the Metaverse

The integration of the Universal Design for Learning (UDL) framework with the Five W's and One H can provide a solid foundation for making a learning framework for the Metaverse, as it takes into account the various dimensions that are important for learning in virtual environments.

UDL focuses on three main dimensions: representation (what), action and expression (how), and engagement (why). These dimensions correspond to the Five W's and One H in the following ways:

- **Representation (what)** corresponds to the "what" in the Five W's and One H, as it involves understanding the content and materials that are being presented to the learner.
- **Action and expression (how)** corresponds to the "how" in the Five W's and One H, as it involves the strategies and methods that learners use to interact with and express their understanding of the material.
- **Engagement (why)** corresponds to the "why" in the Five W's and One H, as it involves understanding the motivations and goals that drive learners to engage with the material.

In addition to these three dimensions, the Five W's and One H framework also highlights other dimensions that are important for learning in the Metaverse:

- **Time (when)** refers to the time frame in which learning takes place and can impact the way that learners approach and engage with the material. This includes the present, past or future events experienced in the Metaverse.
- **Space (where)** refers to the locations in which learning takes place, and can influence the ways in which learners interact with and understand the material. This includes the context and environment for learning experiences in the Metaverse.
- **Identity (who)** refers to the identity and role of the learner within the Metaverse, and can shape the ways in which learners express themselves and interact with others.

By integrating the UDL framework with the Five W's and One H, we can create a learning framework for the Metaverse that takes into account the various dimensions that are important for learning in virtual environments. This can include strategies and methods for presenting materials in ways that are accessible and engaging to learners, as well as strategies for promoting interaction and expression within the Metaverse.

For example, a learning framework for the Metaverse might include the following elements:

- Providing learners with a range of options for representing and interacting with the material, such as text, audio, video, and interactive elements.
- Allowing learners to choose their own pace and path through the material, based on their individual needs and preferences.
- Providing learners with a range of virtual environments and avatars to choose from, in order to facilitate self-expression and identity exploration.
- Encouraging learners to engage with the material and with each other in meaningful and authentic ways, in order to foster a sense of community and connection within the Metaverse.

Consequently, the integration of UDL and the Five W's and One H can provide a solid foundation for making a learning framework for the Metaverse that takes into account the various dimensions that are important for learning in virtual environments.

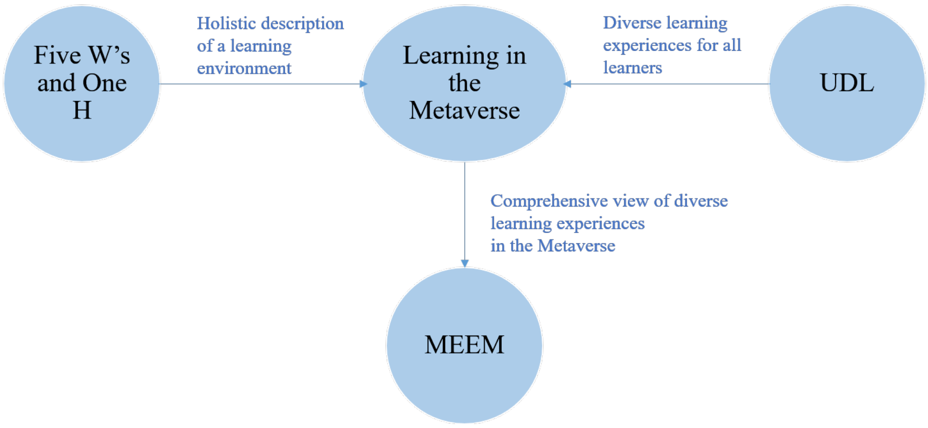
Five W's and One H
Holistic description of a learning environment
Learning in the Metaverse
Diverse learning experiences for all learners
UDL
Comprehensive view of diverse learning experiences in the Metaverse
MEEM

Figure 4.1: Integration of UDL and Five W's and One H for the Metaverse

4.4 MEEM Framework for the Metaverse

Metaverse is a virtual reality (VR) space that enables users to interact with each other inside a computer-generated environment. It has great potential for providing new learning opportunities and revolutionizing the education system. For effective learning to take place in the Metaverse, a cohesive framework referred to as MEEM is proposed to introduce six broad dimensions that guide the design of learning experiences using VR technology. The framework is based on the integration of UDL and Five W's and One H for proposing the important dimensions for learning in the Metaverse.

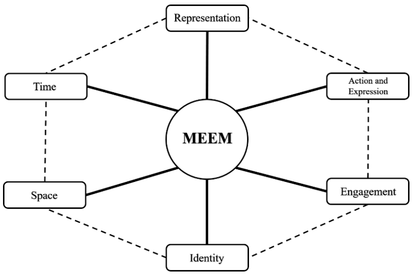

Figure 4.2: Visual Representation of MEEM

a) Representation: The Metaverse provides an enhanced digital reality experience to its users in terms of representation. It uses several sophisticated technologies like AI, Blockchain, and Extended Reality that differ in their core sense from the features of the regular web. In the Metaverse, learners are engaged in multi-sensory experiences to immerse them into a virtual space that reduces the gap between real and virtual worlds. This means the Metaverse has the potential to evoke our senses in a rich visual experience through the use of advanced technologies. This also paves the way for learners to learn in an experiential learning environment where they can participate in the learning process by making efficient use of their senses. The Metaverse aims to provide learners with an improved gamified experience of learning where they can create, share and own assets through the use of NFTs and crypto wallets. This shows the ability to create diverse and interactive content which helps teachers in delivering content in enriching immersive environments. Thus, the Metaverse ensures the learning needs of all learners are taken into account for making learning effective and useful.

To elaborate on the applications of the Metaverse in terms of representation, let us consider a person who is eager to learn counter-steering techniques for riding a motorcycle. For learning this technique, a learner needs to be immersed in an environment where he can experience the physics behind it and see its consequences in real-time. This technique cannot be learned by watching a 2D video or reading a manual or even using a 2D simulator as it requires practical 3D experience. Also, the whole experience of learning can be enhanced using gamification to reinforce the learning experience using rewards. This experience helps the learner to see the real-time results of his actions without suffering physical harm.

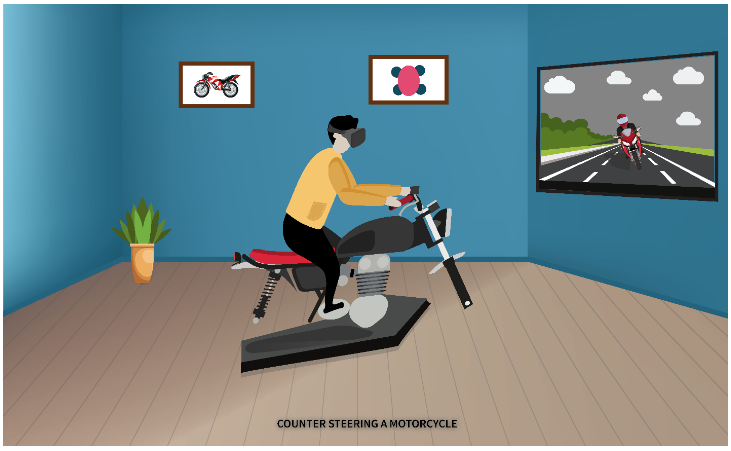

Figure 4.3: Learning counter steering technique in VR using a bike simulator

The Metaverse also has a great potential for maintaining inclusion in the classroom by providing significant learning opportunities for disabled people and allowing them to embrace their true selves. For blind learners, the Metaverse can provide real-time audio and haptic feedback to allow them to experience things that they cannot visually observe. For instance, we can use Augmented Reality to train blind learners to learn cooking. Imagine a kitchen space, overlaid with auditory stimuli, in which every object speaks its name the moment a blind person points his head toward it and the person gets an immediate feedback to keep track of the objects in his surroundings. This allows blind learners to learn cooking while being guided by the auditory stimuli to perform relevant actions.

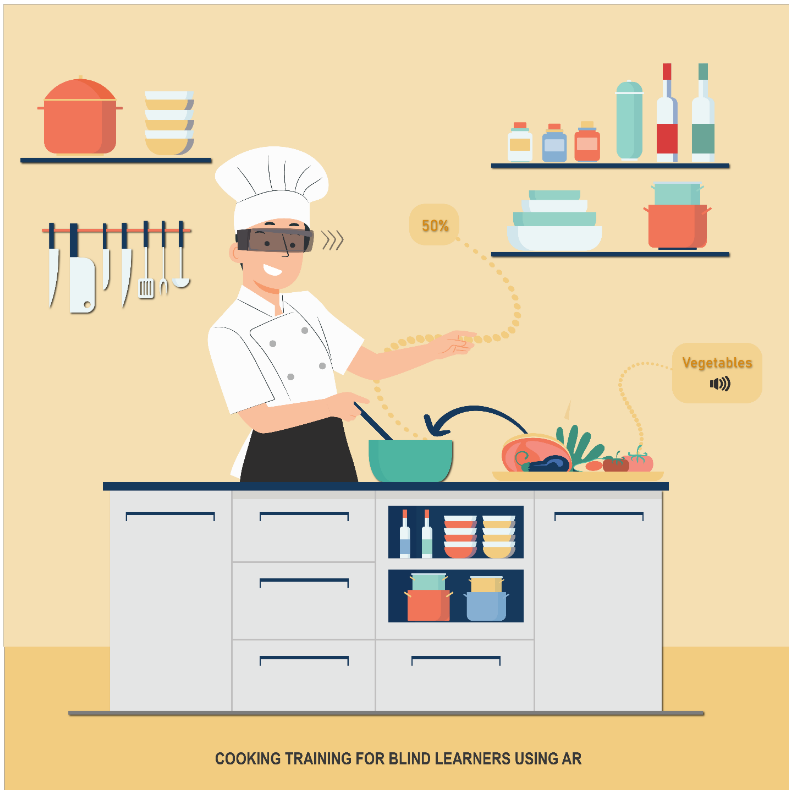
50%
Vegetables
COOKING TRAINING FOR BLIND LEARNERS USING AR

Figure 4.4: Learning to cook in an AR setting overlaid with auditory instructions

The tremendous evolution of Metaverse technology can create a lot of learning opportunities for disabled learners and provide multiple means of representation for them [66, 67]. It is also useful in maintaining an effective learning environment for all learners where they can thrive and learn in an authentic learning context. In this way, the learners can easily highlight relationships between ideas and connect their background knowledge with real-world applications for a smooth transfer of learning to occur. Eventually, learning in immersive environments helps in making learners resourceful and knowledgeable.

b) Action and Expression: The Metaverse enables multiple ways of action and expression by providing a wide array of options to customize avatars in a virtual environment. Because the means of action and self-expression are vital to an immersive experience, the Metaverse allows learners to control their digital identity in the virtual world. It also enables a smooth transition from the social to the spatial web since the latter requires learning experiences to be in a 3D space. The presence of a diverse range of options from 3D games, avatars, and 360-degree virtual tours helps realize the true potential of the Metaverse in learning. Eventually, it allows seamless interaction between people, places, and things in the virtual world and connects humans using advanced networking systems to provide a learning experience that is identical to the physical world [68, 69].

To elaborate on how the Metaverse fosters multiple means of action, let us consider a virtual space in the Metaverse where learners are free to engage themselves in the learning experiences that they desire. Learners who are fond of outdoor sports can learn swimming, paragliding, badminton, and other such activities. Those who are passionate about their creative pursuits can learn to paint, and take dance classes. While some adventure lovers can learn mountain sports from international instructors in parts of the world that are risky to visit.

Another example of multiple means of action in the Metaverse is a virtual space in which learners are allowed to indulge in the kinesthetic learning experiences. Consider a virtual space in which a learner plays tennis, another plays basketball, and the rest of the learners are performing acrobatic moves, walking, and drawing virtual sketches.

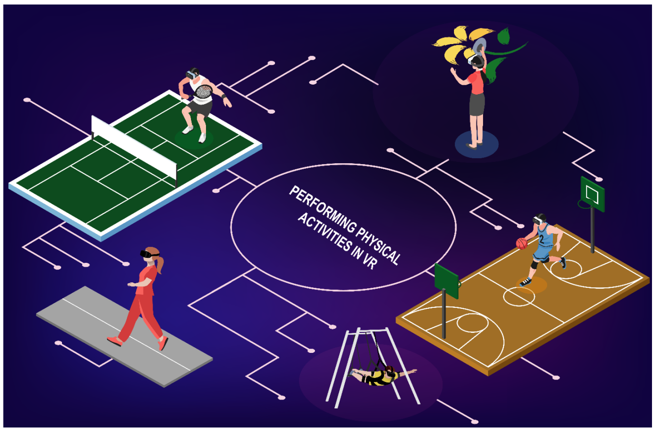
PERFORMING PHYSICAL ACTIVITIES IN VR

Figure 4.5: Kinesthetic learning experiences for learners in VR

Another interesting use case of the Metaverse in terms of the action and expression can be the virtual fashion shows where learners are allowed to practice their walks on ramp, and experience the true spirit of a fashion show to be ready for the actual event. This immersive environment can provide learners with a 3D view of the fashion show that helps them enjoy the authentic experiences.

Figure 4.6: Experiencing fashion shows in VR

Furthermore, the Metaverse provides a space for people from marginalized communities and minority groups to freely express themselves. Imagine a utopian society where all members are allowed to express their beliefs, practice their religious obligations and cultural practices, access quality education and healthcare, and have their basic human rights protected by law. This is the vision that the Metaverse can help us fulfill unless it evolves responsibly with the valuable contributions of all stakeholders (technology experts, educators, policymakers, etc.).

The Metaverse also provides freedom for people to represent themselves as avatars with the skin tones, body shapes, and facial features that they want and empowers disabled people to change their real-world identities and actively participate in activities that were otherwise not possible. For instance, the Metaverse can allow the people of color and people with disabilities to be equal members of the society and enjoy all their rights without facing discrimination on the basic of their color, or disability. In this way, the learners can be safe from the systemic racism and injustice in society.

Another important point to consider is incorporating assistive technology in the Metaverse for leveraging the full potential of the platform to assist people with disabilities and fulfill their learning needs. It can be achieved by building the Metaverse on the principles of accessibility and inclusion so that the systemic barriers that are evident in the real world may be removed in the virtual world. In a nutshell, the possibilities of providing means of action and expression are greatly enhanced in the Metaverse thereby, making learners strategic and goal-directed.

c) Engagement: The Metaverse provides realistic learning experiences to engage learners through the use of augmented and virtual reality. These technologies have the potential to convert traditional learning through textbooks into immersive 3D experiences. There is not one way to engage all learners since it largely depends on different factors such as culture, interests, personal relevance, thought patterns, previous knowledge, and disabilities. Therefore, the Metaverse provides multiple means of engagement through personalized learning experiences and allows them to learn in a 3D environment.

To elaborate on how the Metaverse helps in learners' engagement, let us consider a science learner who is fond of marine life and their habitats. Due to physical constraints, the learner is unable to visit the ocean to explore his interests. Here, the Metaverse can help the learner to visualize ocean life from the comfort of his classroom in an immersive VR environment. The learner is free to explore different types of fish, their habitats, corals, and marine plants and interact with them to have a sound understanding of ocean life. This also enables learners to understand the natural ecosystems and the significance of ocean life in maintaining a healthy balance in the natural environment (climate regulation, oxygen production, etc.). It eventually helps learners empathize with marine animals and take proactive measures to protect the oceans and prevent pollution.

EXPERIENCING OCEAN LIFE IN VR

Figure 4.7: Indulging in the 360-degree view of the ocean life in VR

Another great example of creating engagement through awareness is allowing urban planning students to visualize their city-planning projects in a digital twin in the Metaverse. It will enable them to have a detailed view of the municipalities in a 3D environment and plan their future projects. This use case has great potential to train learners in the realm of urban planning while guiding them to develop eco-friendly projects.

VISUALIZING DIGITAL TWINS USING AR

Figure 4.8: : Visualizing the digital twin of a city project in AR for planning future steps

In the realm of engineering technology, the Metaverse can allow engineers to use digital twins to visualize and interact with technology products before they are physically developed. This allows them to make important decisions about the development process, such as identifying potential design flaws or optimizing the product for specific uses. The digital twins in this environment are highly detailed and accurately represent the physical products, allowing engineers to analyze and test different aspects of the product's performance and functionality. This can be especially useful for complex products or systems that are difficult to prototype or test in the physical world. Using digital twins in the Metaverse, engineers can make informed decisions about the development of technology products, potentially saving time and resources in the development process.

VISUALIZING DIGITAL TWINS OF TECH PRODUCTS

Figure 4.9: Visualizing the digital twins of engineering products for initial review using AR

The Metaverse can provide an opportunity for crime investigation training in the Metaverse. In the Metaverse, new police officers can engage in gamified scenarios that resemble the challenges of the real world and learn effective strategies for countering those challenges. This can help them understand the basics of crime investigation and the practical roles of police officers in ensuring the safety of citizens. Eventually, they will be able to work efficiently in practical settings.

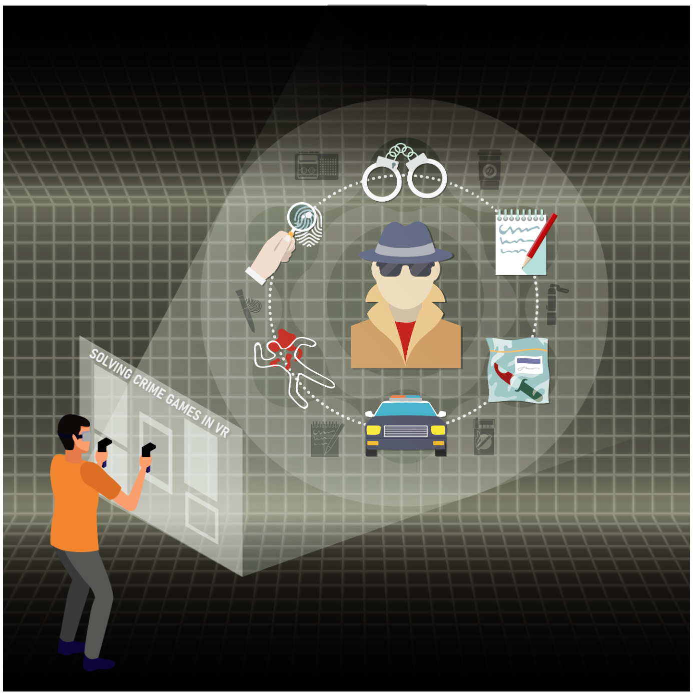
SOLVING CRIME GAMES IN VR

Figure 4.10: A gamified scenario in VR for the crime investigation training of police officers

The Metaverse provides learners with new opportunities to hone their skills in different domains. This will keep them motivated and engaged throughout the learning process and help in meeting their personal interests. For instance, the Metaverse can allow learners to indulge in the practical experiences of Karate training, car driving, shooting, and propelling a ship. This experiential learning environment results in improved retention of learners and better performance in the real world.

LEARNER LEARNING DIFFERENT SKILLS IN VR

Figure 4.11: Demonstration of a learner learning a diverse range of skills in VR

In the case of people with disabilities, Metaverse can provide great opportunities to engage such learners. Let us consider a learner who is interested in learning basketball but is suffering severe impairment which has hindered his ability to communicate and move. The learner can access the Metaverse with a BCI-integrated headset that will allow him to control his motion in the virtual world through his brain (removing the need for controllers). In this way, the learner can choose an avatar to change his real-world identity and actively play his favorite sport in the Metaverse. The Metaverse can offer a breakthrough for people with severe disabilities if it is combined with BCI technologies to enable a full dive into the virtual world. This can pave the way for the inclusion of such people in the Metaverse and promote the effectiveness of the learning environment.

Eventually, immersive environments can offer multiple means of engagement for learners based on their learning needs and train them to be purposeful and motivated. It indicates that the Metaverse comes with new ways to engage learners from different settings and adjust the learning environment to leverage their abilities and reduce their learning barriers.

d) Time: The concept of the Metaverse is similar to a parallel universe that co-exists with our real world but is different in some fundamental ways. This indicates that the Metaverse can help us visit places that are not accessible in the real world. The Metaverse opens an array of opportunities for learners where they can experience events that go beyond the concept of time. On the contrary, traditional learning environments present only a limited set of options to learners where they are not able to experience learning opportunities offered by the Metaverse.

To elaborate on the use cases of the Metaverse in terms of time, let us consider a digital museum in the Metaverse that provides a unique experience to learners to journey through time and space, exploring the ancient past and the vast expanse of the universe. The learners can step back in time to the pre-historic era, where they can witness the majestic dinosaurs that roamed the earth. They can also explore the ancient times of Egyptian rulers, where they can learn about the powerful rulers and their incredible historical legacies. But the journey doesn't stop there – the learners can journey beyond the bounds of our planet and into the depths of outer space. They can discover the wonders of the cosmos, from distant galaxies to our own solar system. This immersive experience of history and science in an enhanced digital environment allows learners to enjoy a deep and transformative learning experience.

DIGITAL MUSEUM WITH DIFFERENT SCENES IN VR

Figure 4.12: Immersive experiences of science and history events in a VR museum

Another use case of the Metaverse is allowing space enthusiasts to go on space expeditions in the virtual world and attain knowledge about celestial objects and space life. While it is nearly impossible for a person to visit the planets and galaxies that are several light-years away, the Metaverse can be used to create realistic 3D experiences of outer space and allow learners to explore its wonders and develop a sound understanding of the subjects like astronomy.

VISITING OUTER SPACE IN VR

Figure 4.13: A travel into the outer space expeditions in VR

Furthermore, in the realm of climate change and sustainability, the Metaverse can educate learners about the history of human actions that have contributed to climate change, as well as the sustainable practices that can be implemented to protect the climate. In this case, it can allow science learners to explore the historical accounts of human actions in the virtual world that led to the degradation of the natural environment and establish a strong ground on creating awareness about this issue. They would also be able to explore sustainable practices, such as renewable energy technologies and conservation efforts, and learn the positive impact of these practices. This type of educational experience could be especially powerful because it allows learners to engage with the material in a hands-on, immersive way that can help them better understand

and remember the concepts being presented.

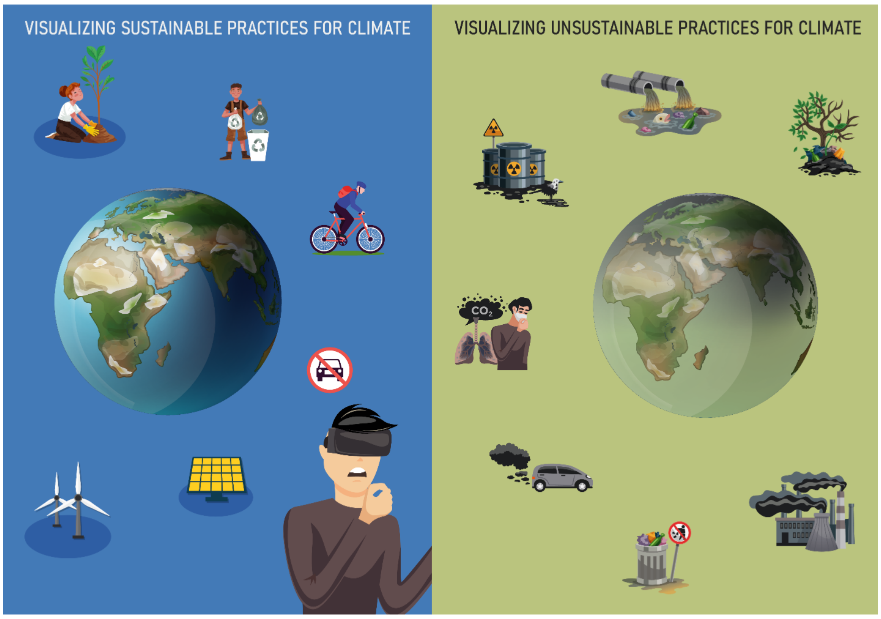
VISUALIZING SUSTAINABLE PRACTICES FOR CLIMATE
VISUALIZING UNSUSTAINABLE PRACTICES FOR CLIMATE
CO₂

Figure 4.14: Visualizing the historical degradation of environment vs future suggestions for climate protection

By leveraging the true potential of the Metaverse, we can create experiences that transcend the boundaries of time and engage learners in learning experiences that were otherwise not possible in the physical world.

e) Space: The Metaverse can provide several opportunities for learners to experience events that are not limited by spatial boundaries. Removing the barrier of space allows learners from remote areas to access similar opportunities in the virtual world. This indicates that there is a possibility of providing quality education to learners and ensuring that they are not deprived of their basic right to education. The immersive environments create engaging, memorable, and impactful learning experiences for learners to improve their learning outcomes and boost their motivation. Such environments also enable the learners to focus on the content and create accessibility for them. Eventually, they will be able to understand complex subjects and become active learners.

To elaborate on the benefits that the Metaverse offers in terms of space, let us consider the use-case of surgical training in the virtual world. Training medical students to accurately perform surgical procedures requires plenty of resources and thus, increases the financial constraints on both the medical colleges and students. Therefore, it is important to offer affordable and sustainable solutions that are equally accessible to students from far-off areas who do not have direct access to training equipment and staff. This barrier can be reduced in the Metaverse where students from all backgrounds can actively participate in surgical training and have a hands-on experience of the critical procedures. It removes a significant burden on both the colleges and students and expands the reach of high-quality surgical training to students belonging to remote and backward areas.

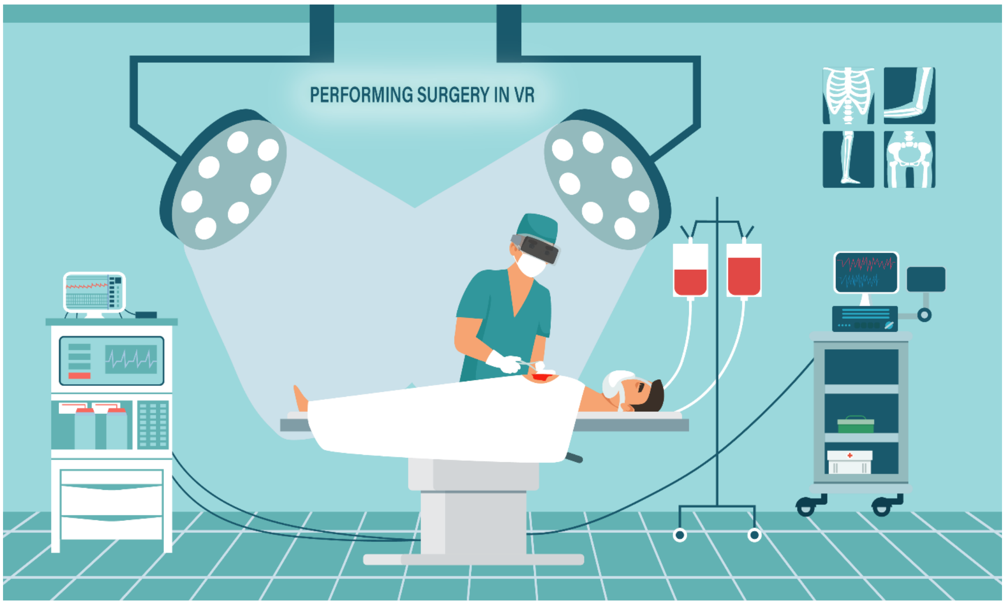

Figure 4.15: Performing critical surgical procedures in VR for training purposes

Furthermore, the Metaverse allows for new opportunities for international collaboration. It can be used to conduct virtual technology expos, allowing attendees to explore and interact with technology products and services in a digital environment. These expos can take the form of virtual trade shows, where attendees can browse and learn about the latest technology offerings from various vendors. They can also include virtual demonstrations and presentations, where attendees can see the technology in action and ask questions about its capabilities and features. In addition, virtual technology expos can include networking opportunities, such as virtual meet-and-greets or chat rooms, where attendees can connect with industry professionals and experts.

The Metaverse can also facilitate student exchange programs by offering an alternative space for students to interact and visit virtual campuses of international universities (so-called ‘metaversities’). It offers learners a useful option to network with representatives of international universities and increases academic collaboration.

Another important use case of the Metaverse is offering disaster response training in the virtual world. As the Metaverse can replicate the real-world context and environment for disaster response training, it tends to provide learners with a safe space to develop their skills in an interactive environment. Consider a scenario in which a learner is using a simulator to learn the skill of fire-fighting. The simulator is a virtual reality environment that simulates a house on fire, and the learner must use their knowledge and training to extinguish the fire. As they work to put out the flames, they are able to practice and hone their skills in a safe and controlled setting. The simulator allows the learner to experience different scenarios and challenges that they may encounter in a real-life fire-fighting situation, such as navigating through smoke-filled rooms or using different fire suppression techniques. Thus, the Metaverse removes the spatial boundaries that limit the learning experiences of learners in the real world and restrain them from enjoying autonomy.

Figure 4.16: Learning fire-fighting techniques using a VR simulator

f) Identity: Identity has an important role in the Metaverse to raise serious concerns surrounding learners' privacy and security due to its fully immersive nature and openness. The increased movement toward immersive digital experiences through technological developments in augmented and virtual realities, the adoption of Blockchain technology in learning management systems, and the enhanced use of gaming worlds in learning have generated significant amounts of data. Due to the lack of strict privacy regulations, learners' data is vulnerable to security breaches. As the Metaverse is able to record sensitive biometric data (heart rate, breathing level, etc.) of individuals to provide personalized learning experiences, it is vital to ensure that learners have control of the information that they want to share.

The Metaverse should ensure strict compliance of data privacy and security. Learners should be allowed to control the use of their information and protect their virtual identities. Because the Metaverse provides options for people to maintain their anonymity, it becomes difficult to authenticate their real-world identities.

Furthermore, the Metaverse gives rise to growing issues on the safety of learners. It can be particularly damaging for kids who might be exposed to instances such as cyberbullying due to the presence of anonymous users. It can also expose children to inappropriate content such as violence and hate speech and increase their addiction to the digital world. Another issue is providing safety and protection to female learners in the Metaverse. Because Metaverse is an embodied form of the Internet, the events of harassment can prove to be more threatening for female learners than those on Web 2.

Other issues might include discrimination against ethnic and minority groups, lack of assistive technology for disabled people, and absence of legal frameworks for addressing crimes. Considering the vision of the Metaverse is to provide equal learning opportunities for all, it becomes essential to take measures to protect the privacy rights of learners. Data privacy, being a fundamental human right, needs to be protected in the Metaverse by making a roadmap for establishing a set of regulations.

An important suggestion is to ensure "privacy-by-design" in the Metaverse is by implementing strong security measures, such as encryption, authentication, and access controls. These measures can help prevent unauthorized access to sensitive data and protect the privacy of learners in the virtual environment. In addition, it is important to establish clear policies and guidelines for the collection, use, and disclosure of personal data in the Metaverse. This can help ensure that the privacy rights of learners are respected and that their data is used in a transparent and responsible manner.

Building the Metaverse on the principle of "privacy-by-design" can also help track malicious attackers in the virtual environment. By designing the Metaverse with strong security measures in place, it becomes more difficult for attackers to gain unauthorized access or compromise the privacy of users. In addition, implementing robust monitoring and logging systems can help identify and trace the activities of malicious actors, allowing administrators to take appropriate action to mitigate the threat and protect the privacy of learners.

By taking into account the ethical issues on the trustworthiness of learning environments in the Metaverse and resolving them through experts' contributions, we can make sure that the Metaverse will be built on globally accepted standards like the regular Internet.

4.5 Considerations for MEEM

There are some important considerations that should be kept in mind for designing learning experiences with MEEM. Each dimension of the MEEM tends to cover some essential aspects for learning in the Metaverse which are discussed below:

- Representation
  - What types of content should be provided in the Metaverse to support diverse learners?
  - How can content be designed to be accessible to all learners in the Metaverse?
  - Why is it important to provide multiple means of representation in the Metaverse?
- Action and Expression
  - How can learners demonstrate their mastery of content in the Metaverse?
  - What types of avatars and body shapes are available for learners to use in the Metaverse?
  - Why is it important for learners to have the ability to freely express themselves in the Metaverse?
- Engagement
  - What types of activities can be used to keep learners engaged in the Metaverse?
  - How can learners be motivated to complete learning activities in the Metaverse?
  - Why is it important to maintain learner engagement in the Metaverse?

- Time
  - What types of learning experiences can be created in the Metaverse that transcend the boundary of time?
  - How can learners participate in learning experiences that take place in different time zones in the Metaverse?
  - Why is it important to create learning experiences that are not restricted by time in the Metaverse?
- Space
  - What types of environments should be created in the Metaverse for different types of learners?
  - How can learners interact with the environment in the Metaverse to support learning?
  - Why is it important to create an environment in the Metaverse that is accessible to all learners?
- Identity
  - What measures can be taken to ensure the safety and security of learners in the Metaverse?
  - How can learners protect their personal information and privacy in the Metaverse?
  - Why is it important to establish rules and regulations to protect the identity of learners in the Metaverse?

4.6 Case Study for MEEM

In recent years, virtual reality and metaverse technologies have revolutionized the way we learn and acquire new skills. The potential of these technologies to create immersive learning experiences that transcend the boundaries of traditional classroom settings has been recognized by leading organizations such as NASA. The Martian metaverse, designed by NASA, is a prime example of how virtual reality can be used to simulate the conditions of Mars and prepare astronauts for future missions. However, designing effective learning experiences in the metaverse requires careful consideration of various factors, which can be achieved through the use of the MEEM framework [70]. The role of MEEM's dimensions in designing the Martian Metaverse is discussed below:

- **Representation:** The representation dimension of MEEM emphasizes the importance of providing multiple means of representation to support diverse learners. In the context of the Martian metaverse, this means providing different types of content such as text, images, and videos to cater to the different learning styles of learners. Additionally, content should be designed to be accessible to all learners, including those with disabilities. For instance, providing captions and audio descriptions can enhance the accessibility of the content.
- **Action and Expression:** The action and expression dimension of MEEM focuses on how learners can demonstrate their mastery of content in the metaverse. In the Martian metaverse, learners can use different types of avatars and body shapes to express themselves and interact with the environment. This enables learners to freely express themselves and engage with the content in a more meaningful way. Moreover, providing different assessment methods such as quizzes and simulations can enhance the learning experience.
- **Engagement:** The engagement dimension of MEEM emphasizes the importance of keeping learners engaged in the learning experience. In the Martian metaverse, this can be achieved through the use of interactive activities such as scavenger hunts and puzzles. Additionally, incorporating game elements such as rewards and badges can motivate learners to complete learning activities and enhance their engagement.
- **Time:** The time dimension of MEEM emphasizes the importance of creating learning experiences that transcend the boundaries of time. In the Martian metaverse, this can be achieved through the use of 3D asynchronous learning experiences that learners can participate in at their own pace. Additionally, creating learning experiences that take place in different time zones can enable learners from different parts of the world to participate in the learning experience.
- **Space:** The space dimension of MEEM focuses on creating an environment in the metaverse that is accessible to all learners. In the Martian metaverse, this

means creating different types of environments to cater to the different needs of learners. For instance, learners with mobility disabilities should be able to navigate the environment easily. Additionally, enabling learners to interact with the environment can enhance their learning experience and engagement.

- **Identity:** The identity dimension of MEEM emphasizes the importance of ensuring the safety and security of learners in the metaverse. In the Martian metaverse, this can be achieved through the establishment of rules and regulations that protect the identity and privacy of learners. Additionally, providing learners with the ability to protect their personal information can enhance their trust in the learning experience.

Thus, it can be observed that MEEM framework provides a comprehensive approach to designing effective learning experiences in the Martian metaverse. By considering the different dimensions of MEEM, NASA can create a more inclusive, engaging, and meaningful learning experience that prepares astronauts for future Mars missions. The use of the MEEM framework can also have broader implications for the design of virtual reality-based learning experiences in other contexts.

Figure 4.17: NASA's Martian Metaverse with astronauts indulging in interactive Metaverse experiences

CHAPTER 5

Ethical Challenges of the Metaverse

Metaverse is a complex and dynamic environment that poses significant threats for learners. Despite the usefulness of the Metaverse for teaching and learning, there are some ethical challenges that need to be addressed to make Metaverse safe for learners. One approach to addressing these challenges is using DEIB Framework which is an ethical framework based on the principles of Diversity, Equity, Inclusion, and Belonging. The role of DEIB in addressing ethical challenges for the Metaverse is discussed below:

5.1 Ethical Challenges of the Metaverse and DEIB Framework

In the Metaverse, DEIB can help to identify and address the ethical challenges that may arise for learners, such as accessibility, representation, stereotypes, cultural sensitivity, harassment and bullying, privacy concerns, intellectual property rights, misuse of technology, legal and regulatory issues, and ethical considerations [71].

This section will explore the ethical challenges of the metaverse through the lens of DEIB, highlighting the importance of considering diversity, equity, inclusion, and belonging in the design and use of metaverse technologies. The section will also provide examples and recommendations for addressing these challenges in order to create inclusive and equitable virtual learning environments.

A) Diversity

Diversity refers to the range of differences and similarities among individuals, including but not limited to race, ethnicity, gender, sexual orientation, age, ability, religion, and cultural background. It is the first element in the DEIB framework and can help address the challenges pertaining to diverse range of learners. In the metaverse, diversity can be challenged by issues such as accessibility and representation.

o Accessibility

One ethical challenge of diversity in the metaverse is accessibility. Metaverse technologies, such as VR and AR, may not be accessible to all learners due to the cost and technical requirements of the hardware. This can create barriers for disadvantaged learners, particularly those who cannot afford the hardware or do not have access to the necessary technology.

For example, VR headsets and AR glasses may be too expensive for some learners, particularly those from low-income families or in developing countries. In addition, the hardware may have technical requirements that are beyond the capabilities of some learners' devices, such as high-end graphics cards or fast internet connections. As a result, these learners may be excluded from participating in metaverse learning environments.

To address this challenge, it is important to consider the accessibility of metaverse technologies when designing and implementing virtual learning environments. This may include providing alternative methods of accessing the virtual world, such as through smartphone apps or web-based platforms, or offering financial assistance or technical support to disadvantaged learners.

o Representation

Another ethical challenge of diversity in the metaverse is representation. Metaverse environments may lack diversity in terms of the representation of characters, avatars, and virtual spaces. This can lead to exclusion and marginalization for learners who do not see themselves represented in the virtual world.

For example, if a metaverse learning environment only offers a limited range of characters or avatars, learners may not have the opportunity to create an avatar that reflects their identity or culture. This can make it difficult for these learners to feel included and valued in the virtual world. Similarly, if a metaverse learning environment only includes virtual spaces that are not representative of the diversity of cultures and experiences of learners, it may not be inclusive or welcoming for all learners.

To address this challenge, it is important to consider the representation of diversity in the design and implementation of metaverse learning environments. This may include offering a range of characters and avatars that reflect the diversity of identities and cultures of learners, as well as including virtual spaces that are representative of the diversity of experiences and backgrounds of learners.

B) Equity

Equity refers to the principles and practices of fairness and justice, including the elimination of barriers and the creation of opportunities for all members of a community to participate and succeed. In the context of DEIB (diversity, equity, inclusion, and belonging), equity is the second element, and it refers to the need to ensure that all members of a community have equal access to opportunities, resources, and support [72].

In the metaverse, equity can be challenged by issues such as representation, stereotypes, cultural sensitivity, and misuse of technology. For example, if certain learners are not represented in the virtual world or are represented in a negative or stereotypical way, this can perpetuate inequities and discrimination. Similarly, if certain learners are excluded or marginalized due to cultural misunderstandings or inappropriate behavior, this can also perpetuate inequities and discrimination.

To address these challenges, it is important to consider equity in the design and implementation of metaverse learning environments. This may include conducting research on the diversity of the learner population, consulting with diverse stakeholders, and using inclusive design principles to create characters, avatars, and virtual spaces that are representative and respectful of all learners. It may also include providing resources and support to disadvantaged learners, establishing policies and procedures to address inappropriate behavior, and ensuring that all learners have equal access to opportunities, resources, and support.

By understanding and addressing the ethical challenges of equity in the metaverse, it is possible to create virtual learning environments that are fair and just for all learners, regardless of their backgrounds or circumstances.

C) Inclusion

Inclusion refers to the active, intentional, and ongoing engagement with diversity in ways that promote and sustain a sense of belonging and respect for all members of a community. It is the third element in the DEIB framework and can help address the issues related to the inclusion of learners. In the metaverse, inclusion can be challenged by issues such as stereotypes, cultural sensitivity, and harassment and bullying.

o Stereotypes

One ethical challenge of inclusion in the metaverse is stereotypes. Metaverse environments may perpetuate harmful stereotypes and biases, particularly if they are not designed with diversity, equity, and inclusion in mind. For example, characters or avatars may be designed with unrealistic or stereotypical physical characteristics, such as overly exaggerated gender or racial features. In addition, virtual spaces may be designed with cultural stereotypes or biases, such as depicting certain cultures or countries in a negative or inaccurate way.

These stereotypes and biases can lead to exclusion and marginalization for learners who do not fit the norm or who do not see themselves represented in a positive or accurate way in the virtual world. To address this challenge, it is important to consider the impact of stereotypes and biases in the design and implementation of metaverse learning environments. This may include conducting research on the diversity of the learner population, consulting with diverse stakeholders, and using inclusive design principles to create characters, avatars, and virtual spaces that are representative and respectful of all learners.

o Cultural sensitivity

Another ethical challenge of inclusion in the metaverse is cultural sensitivity. Metaverse environments may lack cultural sensitivity, leading to misunderstandings and conflicts between learners from different cultural backgrounds. For example, cultural norms and values may not be understood or respected in the virtual world, leading to misunderstandings or misunderstandings between learners from different cultures. In addition, cultural symbols, gestures, or expressions may be used inappropriately or without understanding, leading to offense or discomfort for learners from certain cultures [73].

To address this challenge, it is important to consider cultural sensitivity in the design and implementation of metaverse learning environments. This may include providing resources and training on cultural competency, consulting with diverse stakeholders to ensure cultural sensitivity, and creating virtual spaces that are inclusive and respectful of the diversity of cultural backgrounds and experiences of learners.

o Harassment and bullying

Another ethical challenge of inclusion in the metaverse is harassment and bullying. Metaverse environments may not have the same level of oversight and control as physical environments, leading to an increased risk of harassment and bullying. For example, learners may be able to engage in inappropriate or harmful behaviors in the virtual world without thinking of the possible consequences, such as using offensive language, or engaging in cyberbullying.

To address this challenge, it is important to consider the prevention and management of harassment and bullying in the design and implementation of metaverse learning environments. This may include providing resources and training on appropriate behavior, establishing policies and procedures for reporting and addressing harassment and bullying, and creating a safe and respectful virtual learning environment for all learners.

D) Belonging

Belonging refers to the sense of connection and identification with a community, which can be fostered through inclusivity, respect, and shared experiences. In DEIB framework, it is formed by the overlap of Diversity, Equity and Inclusion, thereby, indicating the importance of these three elements in maintaining a sense of acceptance for learners. In the metaverse, belonging can be challenged by issues such as privacy concerns, intellectual property rights, and ethical considerations.

o Privacy Concerns and Legal Issues

One ethical challenge of belonging in the metaverse is privacy concerns. Metaverse environments may raise privacy concerns, as learners may be sharing personal information and engaging in virtual activities that could be monitored.[74]

Another ethical challenge of belonging in the metaverse is legal and regulatory issues. Metaverse technologies may raise legal and regulatory issues, particularly if they are used for commercial purposes or cross national boundaries. For example, there may be issues around the ownership and use of virtual assets, such as characters, avatars, and virtual spaces. In addition, there may be concerns around data protection and privacy, particularly if personal information is shared or collected in the virtual world [75].

To address these challenges, it is important to consider legal and regulatory issues in the design and implementation of metaverse learning environments. This may include consulting with legal experts and stakeholders, establishing policies and procedures for the use of virtual assets and personal information, and complying with relevant laws and regulations.

Chapter 6

Transformational Learning in the Metaverse

Transformational Learning presents a numerous opportunities for learners to engage in meaningful and deep learning experiences in the Metaverse. To fully harness the potential of transformational learning in the Metaverse, it is important to know how Metaverse and other emerging technologies will contribute to providing a useful platform for transformational learning. By discussing the role of transformational learning in the Metaverse, this chapter will present insights on unlocking the learning potential of the Metaverse.

6.1 Transformational Learning: A Theoretical Background

"Transformational Learning", as defined by Slavich and Zimbardo (2012), is a holistic and transformative process that occurs when individuals experience a significant change in their attitudes, beliefs, and values, leading to a change in behavior [76]. According to the authors, transformational learning is characterized by four key elements: (1) a triggering event or experience, (2) reflection and critical self-examination, (3) the integration of new ideas and experiences, and (4) the transformation of attitudes, beliefs, and values.

La Velle (2020) argues that transformational learning can play a crucial role in the development of critical thinking skills in the Metaverse. The author explains that transformational learning encourages individuals to challenge their existing beliefs and attitudes, leading to a more critical and reflective approach to decision-making. In the context of the Metaverse, this can translate into a more critical and reflective approach to the use and evaluation of technology [77].

Yüner (2020) also argues that transformational learning can play a crucial role in the development of creative problem-solving skills in the Metaverse. The author explains that transformational learning encourages individuals to think outside the box and to take a more flexible and adaptive approach to problem-solving. In the context of the Metaverse, this can translate into a more innovative and creative approach to the use of technology for problem-solving [78].

Omodan and Addam (2022) narrate that transformational learning can play a crucial role in the development of digital competencies in the Metaverse. The authors explain that transformational learning can help individuals to identify their own learning needs, leading to a more active and self-directed approach to learning. Additionally, transformational learning can help individuals to develop a critical perspective on the role of technology in society, leading to the development of ethical and responsible digital practices [79].

To support the above arguments, there are several case studies in education that demonstrate the effectiveness of transformational learning in developing digital competencies, critical thinking, and creative problem-solving skills. For example, a study conducted by Slavich and Zimbardo (2012) showed that transformational learning was effective in developing critical thinking skills among university students. In the study, students were asked to critically reflect on their own experiences with technology and to develop their own ethical framework for the use of technology. The results showed that students who participated in the transformational learning program had a significantly more critical and reflective approach to the use of technology than those who did not participate [76].

Another example comes from Yüner (2020), who conducted a study on the relationship between transformational teaching and students' self-efficacy for learning in higher education [78]. The results showed that students who experienced transformational teaching had a significantly higher level of self-efficacy for learning, indicating that transformational learning can play a crucial role in developing students' ability to adapt to new technologies and situations.

6.2 Transformational Learning and its role in the Metaverse

The Metaverse is an evolving digital reality experience where individuals can interact with each other and digital content in real-time. The potential for the Metaverse to be used for education and learning is vast and provides numerous benefits for learners, including the ability to experience immersive, interactive environments that allow for more active and engaging forms of learning. To realize the full potential of the Metaverse as a learning environment, however, requires a different approach to teaching and learning, known as transformational learning.

Transformational learning is characterized by a change in the learner's basic assumptions, values, beliefs, and perceptions about the world. This type of learning is based on the idea that individuals must first understand their own perspectives, beliefs, and experiences before they can truly understand new information and concepts [80]. Transformational learning is most effective when it is facilitated by a teacher who is able to create a supportive and challenging environment that encourages learners to reflect on their own beliefs, challenge them, and integrate new knowledge and insights into their existing understanding [76].

Transformational learning is particularly helpful in realizing the full potential of the Metaverse as a learning environment because it allows learners to engage in a more active and immersive experience. This is because transformational learning focuses on helping learners develop a deep understanding of the subject matter by encouraging them to reflect on their own experiences and perspectives, and challenging them to think critically about new information and ideas. This type of learning is particularly effective in a Metaverse environment because it allows learners to actively engage with the virtual environment, interact with other learners and teachers, and participate in real-world simulations that help them to apply their understanding in meaningful and relevant ways.

In a Metaverse environment, transformational learning is also beneficial because it provides learners with an opportunity to experience a sense of community and collaboration. This is because the Metaverse is a shared virtual space where learners from different backgrounds and cultures can interact and work together on projects and activities. The collaborative nature of the Metaverse can help learners to develop social and emotional skills, such as communication, empathy, and teamwork, which are critical for success in both personal and professional settings.

Transformational learning also has the potential to be a more equitable form of learning because it values the experiences and perspectives of all learners, regardless of their background or cultural differences. This type of learning is also well-suited to a Metaverse environment because it allows learners to engage with digital content and other learners in ways that are meaningful and relevant to their own experiences and perspectives. This helps to break down traditional barriers to learning, such as socioeconomic status, race, and ethnicity, and makes it possible for all learners to participate in a meaningful and engaging learning experience.

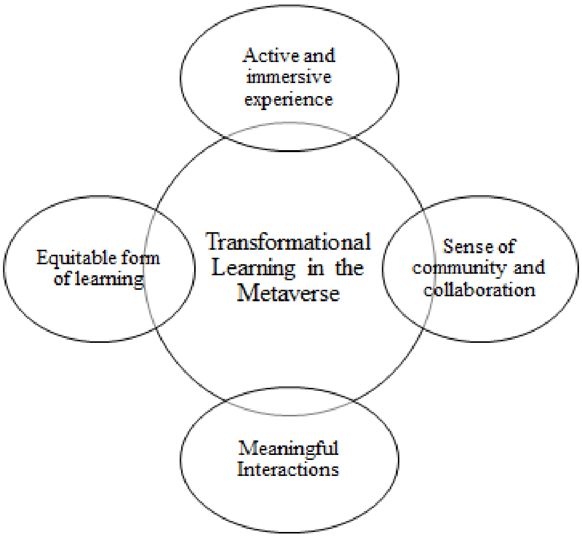
Active and immersive experience
Equitable form of learning
Transformational Learning in the Metaverse
Sense of community and collaboration
Meaningful Interactions

Figure 6.1: Key Elements of Transformational Learning in the Metaverse

6.3 Transformational Learning in the Metaverse: Developing Digital Competencies, Critical Thinking and Creative Problem-Solving Skills

The Metaverse is a rapidly changing digital landscape, characterized by virtual and augmented reality, artificial intelligence, and big data. In such a dynamic environment, it is essential to equip learners with the necessary digital competencies, critical thinking and creative problem-solving skills to thrive. This is where transformational learning comes into play. It is a pedagogical approach that seeks to facilitate the development of learners' potential by promoting meaningful and critical reflection on their experiences. This approach emphasizes the role of the learner in the learning process and fosters a lifelong love of learning.

The Role of Transformational Learning in Developing Digital Competencies

The Metaverse requires learners to have a set of digital competencies to navigate and effectively participate in its virtual environments. These competencies include skills such as digital literacy, digital communication, digital content creation, and problem-solving. According to Omodan and Addam (2022), transformational teaching can help develop these competencies by fostering an environment that encourages learners to reflect on their experiences, experiment with new ideas and technologies, and collaborate with others.

Transformational learning can also help learners develop a growth mindset, which is essential in the Metaverse. In a growth mindset, learners view challenges and failures as opportunities for growth and development, rather than as threats to their self-esteem. As a result, they are more likely to take risks and experiment with new technologies, which can help them develop their digital competencies.

The Role of Transformational Learning in Developing Critical Thinking

In the Metaverse, critical thinking is essential for learners to make informed decisions and solve complex problems. Transformational learning can help learners develop their critical thinking skills by promoting a questioning approach to learning. This approach encourages learners to reflect on their experiences, analyze information, and make informed decisions. According to Slavich and Zimbardo (2012), transformational teaching can help learners develop critical thinking skills by fostering a safe and supportive learning environment, promoting open and honest communication, and encouraging collaboration and reflection.

The Role of Transformational Learning in Developing Creative Problem-Solving Skills

The Metaverse is a constantly evolving landscape, and learners must be able to adapt and solve complex problems to thrive. Transformational learning can help learners develop their creative problem-solving skills by promoting a growth mindset and fostering a love of learning. La Velle (2020) states that transformational teaching can help learners develop creative problem-solving skills by promoting a hands-on and experiential approach to learning. This approach encourages learners to experiment with new ideas and technologies, which can help them develop their problem-solving skills.

Yüner (2020) adds that transformational teaching can also help learners develop their self-efficacy for learning, which is essential for creative problem-solving. Self-efficacy for learning is the belief that one has the ability to succeed in a particular learning situation. When learners have a high level of self-efficacy, they are more likely to take risks and experiment with new technologies, which can help them develop their creative problem-solving skills.

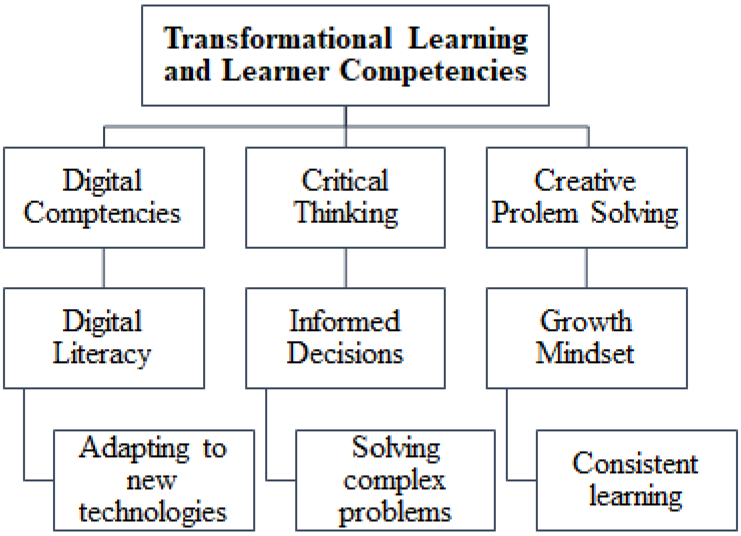

Figure 6.2: Transformational Learning as a way to develop learner competencies in the Metaverse

6.4 Transformational Learning in the Metaverse and the Growth Mindset

Transformational Learning is a process-oriented approach to education that focuses on fostering positive changes in the learner. Unlike traditional learning models, transformational learning emphasizes the individual's personal growth and development, rather than just imparting knowledge. This approach to education is particularly relevant in the Metaverse, where the speed of change is rapidly increasing and where new technologies are constantly emerging.

Developing a Growth Mindset

One of the key benefits of transformational learning is that it helps to foster a growth mindset in learners. A growth mindset is a belief in one's ability to grow and develop through effort and learning. This mindset is important in the Metaverse because it allows learners to approach new challenges with a sense of curiosity and openness, instead of fear and resistance.

A growth mindset can be cultivated through the process of transformational learning, which emphasizes the importance of self-reflection and personal growth. In a transformational learning environment, learners are encouraged to challenge their own beliefs and values, to explore new ideas and perspectives, and to take risks in their learning. This process helps to develop a sense of self-awareness, which is essential for adapting to new technologies and situations in the Metaverse.

The Relationship between Transformational Learning and Gamification

Gamification is the use of game design elements in non-game contexts, such as education. In the Metaverse, gamification is often used to create engaging, interactive learning environments. Transformational learning and gamification are closely related, as both approaches aim to create a learner-centered environment that encourages exploration and experimentation [81].

By incorporating game design elements into the learning process, such as points, levels, and rewards, gamification can create a more engaging and enjoyable learning experience. This is particularly important in the Metaverse, where learners may have limited attention spans and may be easily distracted by other distractions [82, 83].

The relationship between transformational learning and gamification can be seen in the use of game-based pedagogy in the Metaverse. Game-based pedagogy is a teaching approach that uses games and other interactive activities to engage learners and foster learning. This approach aligns well with transformational learning, as it emphasizes the importance of experimentation, exploration, and personal growth.

Case Studies of Transformational Learning in the Metaverse

One example of transformational learning in the Metaverse is the use of virtual reality (VR) simulations. VR simulations allow learners to experience new situations and environments in a safe, controlled environment. For example, a VR simulation of a factory floor can help learners understand the complexities of industrial processes and develop critical thinking skills.

Another example of transformational learning in the Metaverse is the use of gamified learning platforms. Gamified learning platforms, such as Duolingo, provide learners with a fun and engaging way to develop new skills [84]. These platforms often use game design elements, such as points and rewards, to encourage learners to persist in their learning and develop a growth mindset.

Finally, the use of artificial intelligence (AI) in the Metaverse can also support transformational learning. AI-powered tutors and virtual assistants can provide personalized feedback and support to learners, helping to foster a growth mindset and encourage experimentation and exploration.

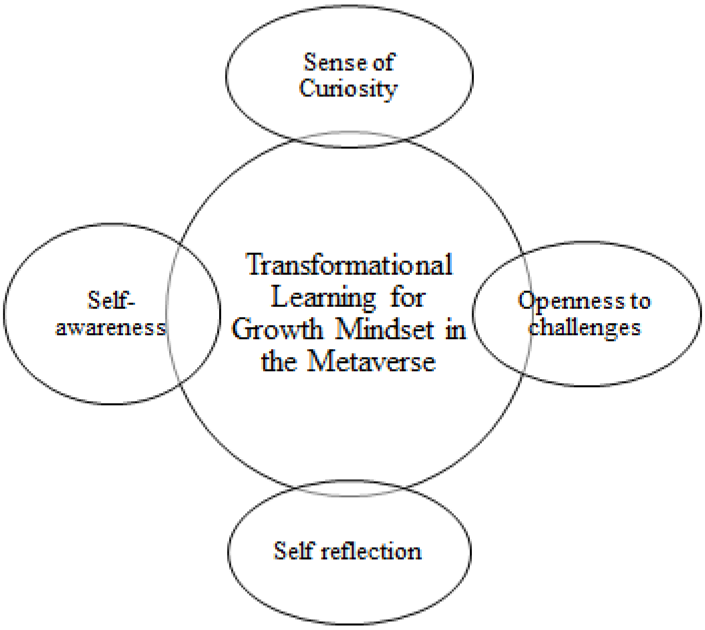

Figure 6.3: Use of Transformational Learning for developing a growth mindset for learners in the Metaverse

6.5 Transformational Learning Experiences: Using Generative AI in the Metaverse

The integration of generative artificial intelligence (AI) in the Metaverse has the potential to revolutionize the way people learn and interact with virtual environments. Generative AI refers to the use of AI algorithms that can generate new data or outputs, such as images, sounds, or text, based on a set of inputs or patterns. In the context of the Metaverse, generative AI can be used to create personalized, adaptive learning experiences that cater to the needs and preferences of individual learners.

It is also important to note that in order to fully realize the potential of generative AI in empowering transformational learning experiences in the Metaverse, it is important to adopt a holistic and collaborative approach. This includes engaging learners in the design and development process, leveraging existing research and best practices in educational technology, and working closely with experts in fields such as AI, psychology, and education. Additionally, it is crucial to consider the ethical and social implications of using generative AI in learning, such as privacy, security, and bias, and to ensure that these concerns are addressed in a transparent and responsible manner [85, 86].

Benefits of Generative AI for Transformational Learning in the Metaverse

1. Customization and Personalization: Generative AI can be used to create customized learning environments and experiences that are tailored to the individual needs and preferences of learners. For example, generative AI can be used to create personalized virtual scenarios and simulations that challenge learners to think critically, solve problems, and make decisions based on real-world contexts.
2. Accessibility and Inclusiveness: Generative AI has the potential to make learning in the Metaverse more accessible and inclusive for marginalized groups, vulnerable populations, and people with disabilities. For instance, generative AI can be used to create virtual learning environments that can accommodate different learning styles, abilities, and disabilities. Additionally, generative AI can be used to provide real-time feedback and support to learners, allowing them to progress at their own pace and on their own terms.
3. Engagement and Motivation: Generative AI has the potential to increase engagement and motivation for learners by providing meaningful and relevant learning experiences that align with their interests and goals. For example, generative AI can be used to create gamified learning experiences that are fun, challenging, and rewarding, encouraging learners to explore and experiment in the Metaverse.

Transformational Learning in the Metaverse and Gen-AI tools

The use of generative AI tools in the Metaverse has the potential to provide innovative and interactive ways of transformational learning. Some of the most prominent generative AI tools that are widely used in the Metaverse are ChatGPT, Midjourney, Stable Diffusion and, DALL-E 2. These tools are designed to enhance the learning experiences of learners and promote a more collaborative, interactive and personalized approach to learning.

ChatGPT, for instance, is a language model developed by OpenAI which can generate human-like text based on the input provided to it. It can be used to provide real-time feedback, personalized learning experiences and conversational learning experiences to learners in the Metaverse. Additionally, ChatGPT can also be used for gamification, personalization and collaboration in learning and teaching environments [87].

Midjourney is another generative AI tool that provides a personalized learning experience to learners in the Metaverse. It uses AI to understand the learning needs and preferences of learners and provides them with personalized recommendations, feedback and guidance. This helps learners to take ownership of their learning journey and encourages a growth mindset.

Stable Diffusion is a generative AI tool that can generate personalized and adaptive learning experiences for learners in the Metaverse. It uses AI algorithms to analyze the learning style, pace, and preferences of learners and provides them with customized and interactive learning experiences. This helps learners to develop a deeper understanding of the concepts they are learning and retain the knowledge for a longer period.

DALL-E 2, developed by OpenAI, is a generative AI tool that uses advanced algorithms to generate images from textual descriptions. It can be used in the Metaverse to provide interactive and engaging learning experiences for learners. For instance, it can be used to generate images and animations that help learners to understand complex concepts, theories and processes.

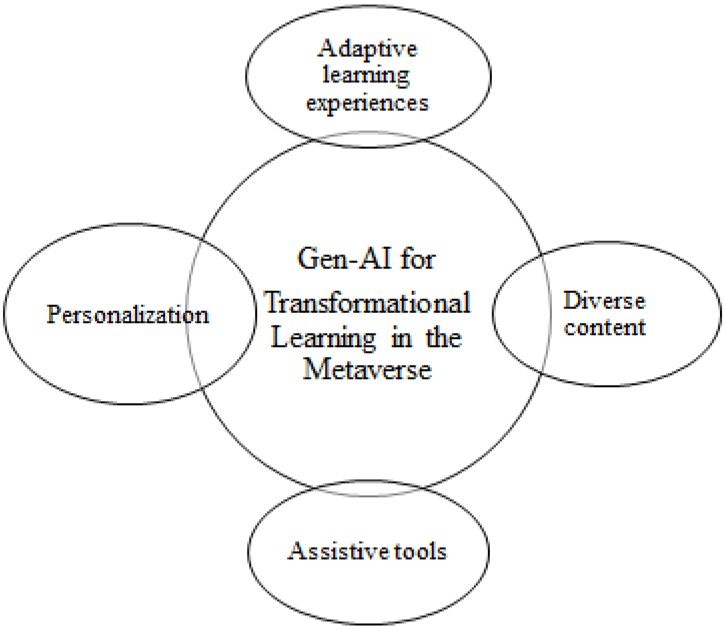
Adaptive learning experiences
Personalization
Gen-AI for Transformational Learning in the Metaverse
Diverse content
Assistive tools

Figure 6.4: Key features of Gen-AI for providing transformational learning experiences in the Metaverse

6.6 Transformational Learning in the Metaverse and Digital Twins

Digital twins provide immense opportunities for driving transformational learning in the Metaverse. Using the technological and pedagogical potential of the Metaverse, new learning opportunities can be introduced using digital twins. The potential applications of digital twins for learning in the Metaverse, the ethical considerations and the significant challenges and opportunities are discussed below:

Utilizing the Potential of the Metaverse in Transformational Learning

The Metaverse is an innovative and revolutionary concept that holds immense potential for transformational learning. By leveraging the power of digital twins, we can create immersive and interactive learning experiences that transcend the limitations of traditional education. In particular, digital twins of prominent scientists of the past and present, such as Richard Feynman, Terrence Tao, David Eagleman, and Noam Chomsky can be employed to foster a deep understanding of the fundamental principles of physics, mathematics, neurocognition and computational linguistics respectively. By designing and developing digital twins of these scientists, we can engage learners in experiential learning that enhances their creativity, critical thinking, and problem-solving skills.

Digital Twin of Richard Feynman

Digital twin of Richard Feynman can be used to teach physics lessons to students from all across the globe. By recreating Feynman's experiments and lectures, learners can gain a deep understanding of the fundamental principles of physics and the scientific method. For example, Feynman's famous lectures on quantum mechanics can be delivered through the digital twin, allowing students to experience the complex world of subatomic particles and their interactions. The digital twin can also simulate Feynman's experiments on liquid helium, providing learners with an interactive and immersive experience that enables them to explore the properties of matter at low temperatures.

Digital Twin of Terrence Tao

Terrence Tao is a renowned mathematician who has made significant contributions to various fields of mathematics, including number theory, harmonic analysis, and partial differential equations. Digital twins of Terrence Tao can be used to provide learners in the Metaverse with highly engaging and interactive math learning experiences. Learners can interact with digital twins of Tao in virtual environments, solving mathematical problems and receiving feedback on their solutions. The digital twins can also be used to create simulations of complex mathematical concepts, making them more accessible and easier to understand for learners. For instance, a digital twin of Tao can be used to teach advanced concepts such as the Riemann Hypothesis or the Birch and Swinnerton-Dyer Conjecture.

Digital Twin of David Eagleman

David Eagleman is a well-known neuroscientist who has conducted extensive research on the brain and perception. Digital twins of Eagleman can be utilized to provide learners with deep insights into the workings of the human brain and how it processes information. These digital twins can be used to create virtual environments where learners can interact with simulations of the human brain and gain a better understanding of how it functions. For example, a digital twin of Eagleman can be used to teach learners about the principles of neural plasticity, which is the brain's ability to adapt and change in response to new experiences. The digital twin can create simulations that demonstrate how the brain's structure changes when learning new information.

Digital Twin of Noam Chomsky

Noam Chomsky is a linguist and philosopher who is well-known for his work on language and cognition. Digital twins of Chomsky can be used to teach learners in the Metaverse about the fundamental principles of language and the underlying cognitive processes that enable humans to understand and produce language. These digital twins can create highly interactive and engaging learning experiences, where learners can interact with simulations of language and cognitive processes. For instance, a digital twin of Chomsky can be used to teach learners about the principles of generative grammar, which is the idea that humans possess an innate ability to produce an infinite number of sentences using a finite set of rules.

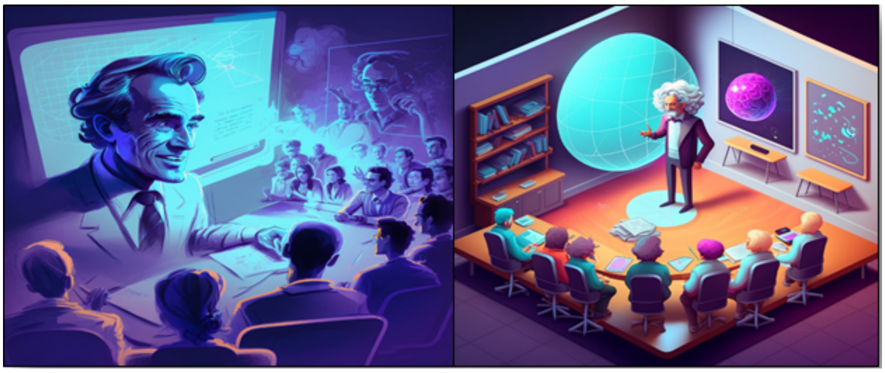

Figure 6.5: Digital twins of Feynman and Eienstin delivering virtual lectures in the Metaverse.

Ethical Issues related to the creation of digital twins

There are several ethical issues related to the creation of digital twins of past scientists and present scientists. One of the main concerns is the use of their likeness without their consent. Some argue that the use of a scientist's image and voice to create a digital twin may violate their right to privacy or their family's right to control the use of their loved one's image. Additionally, there is the issue of accuracy and authenticity. Creating a digital twin of a scientist requires extensive data, including their voice, mannerisms, and thought processes, which can be difficult to gather with complete accuracy. There is also the question of how to ensure that the digital twin accurately represents the scientist's work and beliefs. Finally, there is the risk of the digital twin being used for purposes other than education, such as marketing or propaganda, which could damage the reputation of the scientist or misrepresent their work. As such, it is important to consider these ethical issues and take measures to ensure that the creation and use of digital twins of scientists are done in a responsible and respectful manner [88].

Challenges and Opportunities for using Digital Twins

The use of digital twins in the Metaverse for transformational learning presents several challenges that must be addressed for this technology to be effectively utilized in educational institutions. The first challenge is integrating digital twins with existing learning infrastructure, as not all institutions have the technological capabilities required for seamless integration. Another challenge is the high cost of developing digital twins.

This complex and expensive process may hinder the wider adoption of this technology, despite its potential benefits for transformational learning. Furthermore, the quality of digital twins for transformational learning depends heavily on the quality of data used to train them, and limited access to high-quality data can pose significant challenges, particularly in fields such as neuroscience. Lastly, the Metaverse provides learners with vast amounts of data and simulations, leading to the possibility of information overload. The digital twins of experts can generate enormous amounts of data, which may overwhelm learners and make it difficult for them to identify the essential information required for their learning goals. Without guidance or curation, learners may become disengaged and unable to apply the information effectively.

Despite the potential challenges, digital twins also offer some interesting opportunities for transformational learning in the Metaverse. They can provide personalized learning experiences that adapt to the unique needs and preferences of individual learners, leading to improved engagement and better learning outcomes. Digital twins can also be used to create real-world simulations in a safe and controlled environment, allowing learners to practice and experiment with real-world scenarios without facing any dangerous consequences.

Moreover, digital twins can facilitate collaboration and interaction among learners from different parts of the world. This feature allows them to work together on complex projects and problems in a shared virtual environment. Thus, digital twins can provide enhanced accessibility for learners who face physical or geographical limitations that restrict their ability to participate in traditional learning environments.

Chapter 7

Conclusion and Future Work

This chapter summarizes the key contributions of the research study and suggests useful research directions on learning in the Metaverse. Overall, it will contribute to providing an overview of the research findings in a big picture and discuss their implications for future research studies.

7.1 Conclusion

The concept of the Metaverse that is created by the convergence of both real and virtual reality, has been a subject of fascination and speculation for decades. The term itself was coined in Neal Stephenson's 1992 science fiction novel "Snow Crash". Since then, the concept of the Metaverse has continued to evolve and gain traction as technology has advanced. Today, the Metaverse is becoming increasingly accessible and immersive, with a range of virtual and augmented reality platforms that allow users to interact with digital content and each other in real-time. While the Metaverse is still in its early stages of development, it has the potential to revolutionize the way we think about communication, entertainment, and education.

The future evolution of the Metaverse is likely to be shaped by the developments being made by big tech companies and other industry leaders. These companies are investing heavily in virtual and augmented reality technology, and are working to create increasingly immersive and realistic experiences for users. As the technology continues to advance, it is likely that the Metaverse will become more seamless and integrated with the real world, potentially even blurring the lines between the two. This could lead to a wide range of new applications and opportunities for the Metaverse, including in areas such as education, entertainment, and commerce. Additionally, as the Metaverse becomes more widely adopted, it is likely that new social and cultural norms will emerge, potentially transforming the way we think about and interact with the digital world.

The future of learning in the Metaverse is an exciting and largely unknown territory. As virtual and augmented reality technology continues to advance, it is likely that the Metaverse will become an increasingly popular platform for education and training. The immersive and interactive nature of the Metaverse offers a range of possibilities for experiential learning, allowing learners to directly engage with and explore digital content in a way that is not possible in the physical world. Additionally, the Metaverse allows for real-time collaboration and communication with others, potentially enabling a more social and collaborative approach to learning. While there are still many questions and challenges to be addressed in terms of designing and implementing effective learning experiences in the Metaverse, the potential benefits are significant and worth exploring. Ethical challenges need to be addressed in the Metaverse for its use in education in order to ensure that all learners are treated fairly and have access to the same opportunities. One of the main ethical concerns in the Metaverse is the issue of equity, as there are still significant digital divides that exist in terms of access to technology and the internet. In order for the Metaverse to be used effectively for education, it is important to ensure that all learners have access to the necessary hardware and software, as well as the support and resources they need to fully participate. Additionally, there are potential privacy and security concerns in the Metaverse, as personal data and sensitive information may be shared or accessed in the virtual world. It is important to address these and other ethical issues in order to ensure that the Metaverse is a safe and inclusive space for learning and education.

The given research study contributes to an initial understanding of learning in the Metaverse and its ethical challenges. It proposes a generic framework for highlighting what learning in the Metaverse entails and what broad dimensions affect the learning experiences in the Metaverse. The framework will continue evolving with the research developments in this domain. Moreover, there is still a lot of research required to explore the future of education in the Metaverse and how it is going to change the traditional education systems. As the Metaverse is in its early stages of development, it is important to highlight the crucial roles of all stakeholders for ensuring a responsible growth of this technology.

7.2 Future Work

The given research study on learning in the Metaverse conveys a foundational understanding of the Metaverse and its implications for education. The proposed framework highlights six broad dimensions that are important for learning in the Metaverse. However, the framework only conveys a broad understanding of the dimensions and their possible use cases. The future research should focus on the details of these dimensions and how they can be implemented in different scenarios in education. Furthermore, the future research should be conducted to explore the pedagogical approaches that are effective for learning in the Metaverse and the empirical studies should be done to investigate their effectiveness.

Owing to the lack of research evidence on learning frameworks for the Metaverse, the research study does not include any experimental analyses. Also, a clear and crisp definition of the Metaverse and how it is going to be shaped technologically still remains unexplored. This further makes it difficult to understand the true nature of the Metaverse and what impact it will have on education systems. Due to the technological limitations and lack of substantial research findings on learning frameworks and pedagogies for the Metaverse, the proposed framework could not be applied in the empirical setups. The future research studies can use the proposed framework as a theoretical base for developing useful pedagogies for the Metaverse.

The research study presents a broad understanding of the ethical issues that are likely to appear for learners in the Metaverse. A significant amount of research is required to further investigate the ethical challenges of the Metaverse for marginalized communities, ethnic groups, religious minorities, people of color, and people with disabilities. The future research studies should also investigate the assistive technologies and the accessibility standards for the Metaverse for realizing its full potential.

In a nutshell, the true potential of the Metaverse for different fields, its technological development, and the challenges, opportunities and threats that it poses for society should be thoroughly studied.

References

[1] Joshua, J. (2017). Information bodies: computational anxiety in neal Stephenson's snow crash. Interdisciplinary Literary Studies, 19(1), 17-47.

[2] Dwivedi, Y. K., Hughes, L., Baabdullah, A. M., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M. M., ... & Wamba, S. F. (2022). Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. International Journal of Information Management, 66, 102542.

[3] Jeffs, T., Behrmann, M., & Bannan-Ritland, B. (2005). Assistive technology and literacy learning: Reflections of parents and children. Journal of Special Education Technology, 21(1), 37-44.

[4] Anderson, L., Esser, J., & Interrante, V. (2003, May). A virtual environment for conceptual design in architecture. In Proceedings of the workshop on Virtual environments 2003, 57-63.

[5] Caprara, L., & Caprara, C. (2022). Effects of virtual learning environments: A scoping review of literature. Education and information technologies, 1-40.

[6] Boulton, C. A., Kent, C., & Williams, H. T. (2018). Virtual learning environment engagement and learning outcomes at a 'bricks-and-mortar'university. Computers & Education, 126, 129-142.

[7] Buchholz, F., Oppermann, L., & Prinz, W. (2022). There's more than one metaverse. i-com, 21(3), 313-324.

[8] Sá, M. J., & Serpa, S. (2023). Metaverse as a Learning Environment: Some Considerations. Sustainability, 15(3), 2186.

[9] Lin, H. C. S., Yu, S. J., Sun, J. C. Y., & Jong, M. S. Y. (2021). Engaging university students in a library guide through wearable spherical video-based virtual reality: Effects on situational interest and cognitive load. Interactive Learning Environments, 29(8), 1272-1287.

[10] Lin, H. Y., & He, C. H. (2021). Mobile robot self-localization using omnidirectional vision with feature matching from real and virtual spaces. Applied Sciences, 11(8), 3360.

[11] Wang, Y. T., Lin, K. Y., & Huang, T. (2021). An analysis of learners' intentions toward virtual reality online learning systems: a case study in Taiwan.

[12] Wang, Y., Su, Z., Zhang, N., Xing, R., Liu, D., Luan, T. H., & Shen, X. (2022). A survey on metaverse: Fundamentals, security, and privacy. IEEE Communications Surveys & Tutorials.

[13] Hansil, R. (2021). How gamification mechanics can improve student engagement. Childhood Education, 97(4), 62-67.

[14] Kim, S., Song, K., Lockee, B., Burton, J., Kim, S., Song, K., ... & Burton, J. (2018). What is gamification in learning and education? (pp. 25-38). Springer International Publishing.

[15] Vandercruysse, S., Vandewaetere, M., & Clarebout, G. (2012). Game-based learning: A review on the effectiveness of educational games. Handbook of research on serious games as educational, business and research tools, 628-647.

[16] Amirulloh, M. F. N., & Mulqi, M. (2022). Know more metaverse as the technology of the future. International Journal of Research and Applied Technology (INJURATECH), 2(1), 174-177.

[17] Dionisio, J. D. N., III, W. G. B., & Gilbert, R. (2013). 3D virtual worlds and the metaverse: Current status and future possibilities. ACM Computing Surveys (CSUR), 45(3), 1-38.

[18] Collins, C. (2008). Looking to the future: Higher education in the Metaverse. Educause Review, 43(5), 50-52.

[19] AL-GNBRİ, M. K. (2022). Accounting and auditing in the metaverse world from a virtual reality perspective: A future research. Journal of Metaverse, 2(1), 29-41.

[20] Park, S. M., & Kim, Y. G. (2022). A metaverse: taxonomy, components, applications, and open challenges. IEEE access, 10, 4209-4251.

[21] Cui, L., Zhu, C., Hare, R., & Tang, Y. (2023). MetaEdu: a new framework for future education. Discover Artificial Intelligence, 3(1), 10.

[22] Mystakidis, S. (2022). Metaverse. Encyclopedia, 2(1), 486-497.

[23] Hirsh-Pasek, K., Zosh, J., Hadani, H. S., Golinkoff, R. M., Clark, K., Donohue, C., & Wartella, E. (2022). A whole new world: Education meets the metaverse. Policy.

[24] Van der Merwe, D. (2021, October). The metaverse as virtual heterotopia. In 3rd world conference on research in social sciences (pp. 22-24).

[25] Sandrone, S. (2022). Medical education in the metaverse. Nature Medicine, 1-2.

[26] McStay, A. (2023). The Metaverse: Surveillant Physics, Virtual Realist Governance, and the Missing Commons. Philosophy & Technology, 36(1), 13.

[27] Anderson, J., & Rainie, L. (2022). The metaverse in 2040. Pew Research Centre.

[28] Bojic, L. (2022). Metaverse through the prism of power and addiction: what will happen when the virtual world becomes more attractive than reality?. European Journal of Futures Research, 10(1), 1-24.

[29] Hennig-Thurau, T., Aliman, D. N., Herting, A. M., Cziehso, G. P., Linder, M., & Kübler, R. V. (2022). Social interactions in the metaverse: Framework, initial evidence, and research roadmap. Journal of the Academy of Marketing Science, 1-25.

[30] Yemenici, A. D. (2022). Entrepreneurship in the world of Metaverse: Virtual or real?. Journal of Metaverse, 2(2), 71-82.

[31] Knox, J. (2022). The metaverse, or the serious business of tech frontiers. Postdigital science and education, 4(2), 207-215.

[32] Lo, S. C., & Tsai, H. H. (2022). Design of 3D Virtual Reality in the Metaverse for Environmental Conservation Education Based on Cognitive Theory. Sensors, 22(21), 8329.

[33] Lee, E. A. L., Wong, K. W., & Fung, C. C. (2010). How does desktop virtual reality enhance learning outcomes? A structural equation modeling approach. Computers & Education, 55(4), 1424-1442.

[34] Mandal, S. (2013). Brief introduction of virtual reality & its challenges. International Journal of Scientific & Engineering Research, 4(4), 304-309.

[35] Stavroulia, K. E., & Lanitis, A. (2017). On the potential of using virtual reality for teacher education. In Learning and Collaboration Technologies. Novel Learning Ecosystems: 4th International Conference, LCT 2017, Held as Part of HCI International 2017, Vancouver, BC, Canada, July 9-14, 2017, Proceedings, Part I 4 (pp. 173-186). Springer International Publishing.

[36] Contreras, G. S., González, A. H., Fernández, M. I. S., Martínez, C. B., Cepa, J., & Escobar, Z. (2022). The importance of the application of the metaverse in education. Modern Applied Science, 16(3), 1-34.

[37] Salta, K., Paschalidou, K., Tsetseri, M., & Koulougliotis, D. (2022). Shift from a traditional to a distance learning environment during the COVID-19 pandemic: university students' engagement and interactions. Science & Education, 31(1), 93-122.

[38] Bashir, A., Bashir, S., Rana, K., Lambert, P., & Vernallis, A. (2021). Post-COVID-19 adaptations; the shifts towards online learning, hybrid course delivery and the implications for biosciences courses in the higher education setting. In Frontiers in Education (p. 310). Frontiers.

[39] Huang, R. H., Liu, D. J., Tlili, A., Yang, J. F., & Wang, H. H. (2020). Handbook on facilitating flexible learning during educational disruption: The Chinese experience in maintaining undisrupted learning in COVID-19 outbreak. Beijing: Smart Learning Institute of Beijing Normal University, 46.

[40] Dillenbourg, P. (1999). What do you mean by collaborative learning?.

[41] Barkley, E. F., Cross, K. P., & Major, C. H. (2014). Collaborative learning techniques: A handbook for college faculty. John Wiley & Sons.

[42] Deci, E. L., & Ryan, R. M. (2000). The" what" and" why" of goal pursuits: Human needs and the self-determination of behavior. Psychological inquiry, 11(4), 227-268.

[43] Wong, D., & Floridi, L. (2022). Meta's Oversight Board: a review and critical assessment. Minds and Machines, 1-24.

[44] Zvarikova, K., Cug, J., & Hamilton, S. (2022). Virtual Human Resource Management in the Metaverse: Immersive Work Environments, Data Visualization Tools and Algorithms, and Behavioral Analytics. Psychosociological Issues in Human Resource Management, 10(1), 7-20.

[45] De Decker, P., & Peterson, S. (2020). Beyond Virtual or Physical Environments: Building a Research Metaverse A White Paper for NDRIO's Canadian Digital Research Needs Assessment. Canada: NDRIO.

[46] Seabra, G. A., & Santos, L. A. Metaverse and NewsGames—two sides of the same coin.

[47] Quinones, P. A., Vora, J., Steinfeld, A., Smailagic, A., Hansen, J., Siewiorek, D. P., ... & Shah, A. (2008, September). The effects of highlighting and pop-up interruptions on task performance. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting (Vol. 52, No. 3, pp. 177-181). Sage CA: Los Angeles, CA: SAGE Publications.

[48] Kaddoura, S., & Al Husseiny, F. (2023). The rising trend of Metaverse in education: challenges, opportunities, and ethical considerations. PeerJ Computer Science, 9, e1252.

[49] Thomas, A. Metaverse market size worldwide 2022-2030, statista (2023)

[50] Makransky, G., & Mayer, R. E. (2022). Benefits of taking a virtual field trip in immersive virtual reality: Evidence for the immersion principle in multimedia learning. Educational Psychology Review, 34(3), 1771-1798.

[51] Koksal, I. (2020). The rise of online learning. Forbes.

[52] Dumford, A. D., & Miller, A. L. (2018). Online learning in higher education: exploring advantages and disadvantages for engagement. Journal of computing in higher education, 30, 452-465.

[53] Cozzens, S., & Thakur, D. (Eds.). (2014). Innovation and inequality: Emerging technologies in an unequal world.

[54] Qamar, S., Anwar, Z., & Afzal, M. (2023). A systematic threat analysis and defense strategies for the metaverse and extended reality systems. Computers & Security, 103127.

[55] Davis, N. (2016). Long-term effects of virtual reality use need more research, say scientists. The Guardian, International edition.

[56] Kandaurova, M., & Lee, S. H. M. (2019). The effects of Virtual Reality (VR) on charitable giving: The role of empathy, guilt, responsibility, and social exclusion. Journal of Business Research, 100, 571-580.

[57] Wang, Y., Lee, L. H., Braud, T., & Hui, P. (2022, July). Re-shaping Post-COVID-19 teaching and learning: A blueprint of virtual-physical blended classrooms in the metaverse era. In 2022 IEEE 42nd International Conference on Distributed Computing Systems Workshops (ICDCSW) (pp. 241-247). IEEE.

[58] Kshetri, N. (2022). Metaverse and Developing Economies. IT Professional, 24(4), 66-69.

[59] Swedberg, R. (2020). Exploratory research. The production of knowledge: Enhancing progress in social science, 17-41.

[60] Rose, D. (2000). Universal design for learning. Journal of Special Education Technology, 15(4), 47-51.

[61] Wang, M., Yu, H., Bell, Z., & Chu, X. (2022). Constructing an Edu-metaverse ecosystem: a new and innovative framework. IEEE Transactions on Learning Technologies, 15(6), 685-696.

[62] Dinmore, S. P. (2014). The case for universal design for learning in technology enhanced environments. International Journal of Cyber Ethics in Education (IJCEE), 3(2), 29-38.

[63] He, Y. (2014). Universal design for learning in an online teacher education course: Enhancing learners' confidence to teach online. MERLOT Journal of Online Learning and Teaching, 10(2), 283-298.

[64] Cumming, T. M., & Rose, M. C. (2022). Exploring universal design for learning as an accessibility tool in higher education: A review of the current literature. The Australian Educational Researcher, 49(5), 1025-1043.

[65] Saker, M., & Frith, J. (2022). Contiguous identities: the virtual self in the supposed metaverse. First Monday.

[66] Seigneur, J. M., & Choukou, M. A. (2022, May). How should metaverse augment humans with disabilities?. In 13th Augmented Human International Conference (pp. 1-6).

[67] Sghaier, S., Elfakki, A. O., & Alotaibi, A. A. (2022). Development of an intelligent system based on metaverse learning for students with disabilities. Frontiers in Robotics and AI, 9.

[68] Chenna, S. (2023). Augmented Reality and AI: Enhancing Human-Computer Interaction in the Metaverse. Available at SSRN 4324629.

[69] Han, Z., Tu, Y., & Huang, C. (2023). A framework for Constructing a Technology-enhanced Education Metaverse: Learner Engagement with Human–machine Collaboration. IEEE Transactions on Learning Technologies.

[70] Bychiloe, T., NASA is offering $70k as a prize for the best design for a Martian metaverse to help train astronauts, Fortune (2022).

[71] Maltbia, T. E., & Prior, D. M. (2023). Race: Ethical perspectives on equity-based coaching. The Ethical Coaches' Handbook: A Guide to Developing Ethical Maturity in Practice.

[72] Willard, W. G., Van Dam, B., Bermiss, Y. S., Nwogu, C., Viernes, N., & King, S. (2023, March). How Simulating Difficult Conversations in Virtual Reality Around Diversity, Equity, and Inclusion Benefits Interpersonal Skills Training. In Society for Information Technology & Teacher Education International Conference (pp. 1223-1228). Association for the Advancement of Computing in Education (AACE).

[73] Perriguey, G. (2023). Student emotions in virtual reality: The concept of psychopedagogy by design. In Immersive education: Designing for learning (pp. 51-69). Cham: Springer International Publishing.

[74] Vondráček, M., Baggili, I., Casey, P., & Mekni, M. (2023). Rise of the metaverse's immersive virtual reality malware and the man-in-the-room attack & defenses. Computers & Security, 127, 102923.

[75] Ponkin, I. (2023). Metaverse: Legal Perspective. International Journal of Open Information Technologies, 11(1), 118-127.

[76] Slavich, G. M., & Zimbardo, P. G. (2012). Transformational teaching: Theoretical underpinnings, basic principles, and core methods. Educational psychology review, 24, 569-608.

[77] la Velle, L. (2020). Teacher education: the transformation of transitions in learning to teach. Journal of Education for Teaching, 46(2), 141-144.

[78] Yüner, B. (2020). Transformational Teaching in Higher Education: The Relationship between the Transformational Teaching of Academic Staff and Students' Self-Efficacy for Learning. Educational Policy Analysis and Strategic Research, 15(4), 350-366.

[79] Omodan, B. I., & Addam, B. (2022). Analysis of Transformational Teaching as a Philosophical Foundation for Effective Classrooms. Journal Of Curriculum Studies Research, 4(2), 15-29.

[80] Dali, A. K. (2023). The Impact of Transformational and Transactional Leadership, Organizational Culture, and Learning Organization toward Employee Satisfaction on ABC International School in Surabaya. International Journal of Science and Business, 18(1), 15-26.

[81] Tan, W. K., Sunar, M. S., & Goh, E. S. (2023). Analysis of the college underachievers' transformation via gamified learning experience. Entertainment Computing, 44, 100524.

[82] Bartolotta, S., Gaggioli, A., & Riva, G. (2023). The META-Learning Project: Design and Evaluation of an Experiential-Learning Intervention in the Metaverse for Soft Skills Improvement. Cyberpsychology, Behavior, and Social Networking, 26(3), 221-224.

[83] Hou, H. T. (2023). Diverse Development and Future Challenges of Game-Based Learning and Gamified Teaching Research. Education Sciences, 13(4), 337.

[84] Shortt, M., Tilak, S., Kuznetcova, I., Martens, B., & Akinkuolie, B. (2023). Gamification in mobile-assisted language learning: A systematic review of Duolingo

literature from public release of 2012 to early 2020. Computer Assisted Language Learning, 36(3), 517-554.

[85] Ratican, J., Hutson, J., & Wright, A. (2023). A Proposed Meta-Reality Immersive Development Pipeline: Generative AI Models and Extended Reality (XR) Content for the Metaverse. Journal of Intelligent Learning Systems and Applications, 15.

[86] Du, H., Li, Z., Niyato, D., Kang, J., Xiong, Z., Huang, H., & Mao, S. (2023). Generative AI-aided optimization for AI-generated content (AIGC) services in edge networks. arXiv preprint arXiv:2303.13052.

[87] González-González, C. S., Muñoz-Cruz, V., Toledo-Delgado, P. A., & Nacimiento-García, E. (2023). Personalized Gamification for Learning: A Reactive Chatbot Architecture Proposal. Sensors, 23(1), 545.

[88] Adjei, P., & Montasari, R. (2023). A critical overview of digital twins. Research Anthology on BIM and Digital Twins in Smart Cities, 1-12.